



CMS Member Profile:  
Dr. Edgar G. Goodaire

9

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**CMS**  
**SMC**

Canadian Mathematical Society  
Société mathématique du Canada

# CMS NOTES de la SMC

March  
April  
2014

## Vice-President's Notes

**Robert van den Hoogen**, *Vice-President – Atlantic*

## The Perception of the Value of Using Public Funds in Academia



**A**cross the country, roughly 55% of the operating costs of the University sector comes from the public purse (i.e., taxpayers' dollars)<sup>1,2</sup>.

Different provincial jurisdictions will have different proportions, but in all cases it is a non-trivial amount.

This most recent past holiday season spent with family, like many other family oriented events, has laid bare the need for me, and indeed for the entire academic community, to better justify our continuing reliance on public funds. For context, I am the only academic in my extended family. All the others are farmers, mechanics, teachers, pharmacy technicians, iron-workers, or home-makers, amongst other professions. After 18 years working in academia, I at last no longer hear the phrase "so you are off for the summer, eh" repeated year after year. In the past, I usually took this opportunity to explain that as an academic, I have responsibilities that lie outside the realm of teaching from September through April. Of course, now that I have convinced my family and friends that I do not have a four month vacation, they invariably ask me, to what exotic place will I be travelling to this year to present my research. I have participated in many Canadian and International conferences in both my discipline and in broader cross discipline conferences such as the CMS meetings. Now I have to explain and justify to my siblings,

in-laws, etc., why I must actually go to Ottawa, or Madrid or Winnipeg to participate in the conferences, and to present my research. I also have to explain that the funding for the travel to these conferences comes from within the University or directly from my NSERC Discovery Award.

So, my family asks, if this is not a vacation, why am I paying you to go to Madrid, Paris, Ottawa and San Antonio? What is the direct benefit to me?

It is this question that I sometimes find very difficult to answer adequately. Telling my family that studying alternative theories of gravity allows one to have greater understanding of the underpinnings of the Universe itself is somehow not sufficient. I have extreme difficulty in showing how there is a direct and tangible benefit to them and society in the broadest terms at the present time. Perhaps this is just my personal failure to explain adequately the present and more importantly the future value of my research.

But I don't think I'm alone. I do not think that in general any academics do enough to justify their research expenditures to the general public, and as mathematicians, due to the very nature of the topics and problems we work on, we are at an even greater disadvantage. Over the past couple of years, I have had the opportunity to question NSERC representatives on the direction of NSERC and the reasons why they have implemented so many changes in the past 5-8 years. While the people on the ground at NSERC realize the present and future value of fundamental research, they too are feeling the need and pressure for greater accountability to the public.

<sup>1</sup> FINANCIAL INFORMATION OF UNIVERSITIES AND COLLEGES 2011/2012 ([http://www.caubo.ca/sites/137.149.200.5/pilot/files/CAUBO\\_2011-2012\\_FINANCIAL\\_INFORMATION\\_OF\\_UNIVERSITIES\\_AND\\_COLLEGES.pdf](http://www.caubo.ca/sites/137.149.200.5/pilot/files/CAUBO_2011-2012_FINANCIAL_INFORMATION_OF_UNIVERSITIES_AND_COLLEGES.pdf))

<sup>2</sup> CAUT Almanac of Post-secondary Education in Canada / Almanac de l'enseignement postsecondaire au Canada de l'ACPPU ([http://www.caut.ca/docs/default-source/almanac/almanac\\_2013-2014\\_print\\_final.pdf](http://www.caut.ca/docs/default-source/almanac/almanac_2013-2014_print_final.pdf))

## Math is ubiquitous



**Srinivasa Swaminathan,**  
*Dalhousie University, Halifax, NS*

Once in a while a colleague drops into my office and asks: 'What book are you reading that you don't have to?' The conversation then veers towards discussing my answer. Generally my habit is to read mathematically related books. These may concern either research or writing reviews or just general reading.

Essays, interviews and reminiscences concerning mathematicians are among the most interesting items. Two books, *Mathematical People*, and *More Mathematical People* [1, 2] give accounts of interviews with top mathematicians of the last century. These interviews and profiles provide interesting anecdotes of famous mathematicians. We read how parents helped their children during the school stages – at age eleven, Lipman Bers was taught mathematical induction, and a proof of the Pythagoras theorem by his father. Teachers and principals of schools inculcate enthusiasm for mathematical ideas. Paul Cohen, famous for solving the problem relating to continuum hypothesis, started looking at problems in the algebra book of his sister who then bought him a book on school geometry which turned out to be an eye-opener for him to understand proofs. Irving Kaplansky showed his fourth grade teacher that squares always end in 0, 1, 4, 5, 6 or 9. Fred Mosteller got smitten by mathematical elegance when he learnt that a generating function would determine the probability that three dice will show a sum of 10, without having to write down all the combinations and count!

Want to read something light and yet interesting? I would recommend the two volumes of *Mathematical Apocrypha* by Steven G. Krantz [3]. These consist of stories and anecdotes, strictly mathematical, about persons who adhere to mathematics but cannot strictly be called mathematicians.

Do you know the pizza version of the Pythagorean theorem? It provides an answer to the question: which gives you more pizza – the small pizza + the medium pizza or the large pizza itself? Look into the book *777 Mathematical Conversation Starters* by John de Pillis [4]; this book contains thought provoking vignettes, nice quotes, poems, cartoons etc, all related to mathematics in some way.

Thus a mathematician has never a dull moment; he or she can be ever busy with their own research or a book of interesting problems such as *Roots to Research* by Judith D. Sally and Paul Sally, Jr.[5]

1. *Mathematical People*, edited by Donald J. Albers & Gerald L. Anderson 2<sup>nd</sup> edition, A. K. Peters, 2008
2. *More Mathematical People*, edited by Donald J. Albers, Gerald L. Anderson and Constance Reid, Academic Press, 1990
3. *Mathematical Apocrypha*, by Steven G. Krantz, MAA 2002
4. *777 Mathematical Conversation Starters*, by John de Pillis, MAA 2002
5. *Roots to Research* by Judith D. Sally and Paul Sally, Jr. AMS 2007.

## L'omniprésence des mathématiques

De temps à autre, un collègue débarque dans mon bureau et me demande ce que je lis en ce moment par plaisir. La conversation finit presque toujours par une discussion sur ma réponse. C'est que j'ai l'habitude de lire des livres sur les mathématiques. Parfois en lien avec mes recherches ou mes fonctions de critique, mais aussi parfois des bouquins que je lis simplement par intérêt personnel.

Les essais, les entrevues et les souvenirs qui portent sur les mathématiciens sont généralement les plus intéressants. Deux livres, soit *Mathematical People* et *More Mathematical People* [1, 2], présentent des entrevues avec de grands mathématiciens du dernier siècle. Ces entrevues et profils contiennent d'intéressantes anecdotes sur des mathématiciens célèbres. On y apprend par exemple de quelle façon les parents aidaient leurs enfants dans leur parcours scolaire – à onze ans, Lipman Bers s'est fait enseigner l'induction mathématique et une preuve du théorème de Pythagore par son père. Comment les enseignants et directeurs d'école transmettent leur enthousiasme par rapport aux idées mathématiques. Que Paul Cohen, devenu célèbre pour avoir résolu le problème lié à l'hypothèse du continu, a commencé à s'intéresser à des problèmes qu'il trouvait dans le manuel d'algèbre de sa sœur, qui lui a alors apporté un manuel scolaire de géométrie : ce fut pour lui la révélation qui l'a amené vers la compréhension des preuves. Comment Irving Kaplansky a démontré à son enseignant de quatrième année que les nombres carrés se terminent toujours par 0, 1, 4, 5, 6 ou 9. Et que Fred Mosteller a été frappé par l'élégance mathématique le jour où il a appris qu'une fonction génératrice pouvait déterminer la probabilité que trois dés donnent une somme de 10 sans avoir à écrire toutes les combinaisons possibles et les compter!

Pour une lecture légère et intéressante, je recommande les deux volumes de *Mathematical Apocrypha* de Steven G. Krantz [3]. Ils proposent des histoires et des anecdotes, toutes mathématiques, au sujet de personnes associées aux mathématiques, mais que l'on ne considérerait pas comme des mathématiciens proprement dits.

Connaissez-vous la version « pizza » du théorème de Pythagore? Elle répond à la question : qu'est-ce qui donne la plus grande quantité de pizza, une petite + une moyenne, ou une grande pizza? Cherchez la réponse dans l'ouvrage *777 Mathematical Conversation Starters* de John de Pillis [4]; il contient des vignettes, de belles citations, des poèmes, des animations et autres éléments qui portent à réflexion, tous liés aux mathématiques d'une façon ou d'une autre.

Ainsi, un mathématicien ne s'ennuie jamais; il peut vaquer à ses propres recherches ou se plonger dans la lecture d'un ouvrage de problèmes intéressants comme *Roots to Research* de Judith D. Sally et Paul Sally, Jr.[5]

1. *Mathematical People*, sous la direction de Donald J. Albers et Gerald L. Anderson, 2<sup>e</sup> édition, A. K. Peters, 2008
2. *More Mathematical People*, sous la direction de Donald J. Albers, Gerald L. Anderson et Constance Reid, Academic Press, 1990
3. *Mathematical Apocrypha* de Steven G. Krantz, MAA 2002
4. *777 Mathematical Conversation Starters* de John de Pillis, MAA 2002
5. *Roots to Research* de Judith D. Sally et Paul Sally, Jr. AMS 2007.

Robert van den Hoogen, *vice-président – Atlantique*

## La perception du financement public de la recherche



Partout au pays, environ 55 % des coûts de fonctionnement des universités sont couverts par les deniers publics, c'est-à-dire l'argent des contribuables<sup>1,2</sup>. Même si les proportions varient d'une province à l'autre, on parle tout de même de montants appréciables.

Aux dernières Fêtes, comme lors de bien d'autres rencontres familiales, j'ai constaté une fois de plus à quel point il était temps que les chercheurs justifient mieux leur dépendance aux fonds publics, un constat qui s'impose pour l'ensemble du milieu universitaire.

Je m'explique. Parmi les membres de ma famille élargie, je suis le seul universitaire. Les autres travaillent en agriculture, en mécanique, en éducation, en pharmacie et en construction, ou élèvent une famille, par exemple. Heureusement, après 18 ans de carrière à l'université, je n'entends plus la phrase « comme ça, t'es en congé pour l'été? » année après année. Avant, je profitais de l'occasion pour leur expliquer que les professeurs d'université ont d'autres responsabilités que d'enseigner de septembre à avril. Naturellement, maintenant que mes proches ont compris que je n'ai pas quatre mois de vacances, ils tiennent invariablement à savoir dans quel lieu exotique j'irai présenter mes recherches cette année. J'ai participé à de nombreuses conférences disciplinaires et interdisciplinaires au Canada et à l'étranger, dont celles de la SMC. Par conséquent, je dois maintenant expliquer aux beaux-parents et à tous les autres pourquoi il est important que j'assiste à ces conférences et que j'aie à présenter mes travaux à Ottawa, Madrid ou Winnipeg. Je dois aussi leur expliquer que mes frais de voyage sont couverts par l'université ou par ma propre Subvention à la découverte du CRSNG.

Alors, si ce ne sont pas des vacances, me répond-on, pourquoi dois-je payer tes voyages à Madrid, Paris, Ottawa ou San Antonio? Qu'est-ce que j'en retire? Je trouve souvent difficile de formuler une réponse convaincante à cette question. Pour une raison quelconque, leur dire que l'étude des différentes théories de la gravitation permet de mieux comprendre les fondements mêmes de l'univers me semble insuffisant... J'ai énormément de difficulté à leur démontrer que mon travail a des retombées directes et concrètes pour eux et la société contemporaine.

Il s'agit peut-être d'une simple incapacité personnelle d'expliquer adéquatement la valeur actuelle et, surtout, future de mes travaux. Mais je ne pense pas que je suis le seul. Il me semble qu'en général, aucun universitaire ne cherche assez à justifier ses frais de recherche auprès du public. Compte tenu de la nature même des problèmes et des sujets qui nous occupent, les mathématiciens sont encore plus désavantagés.

Au cours des dernières années, j'ai eu l'occasion d'interroger des représentants du CRSNG sur les orientations de l'organisme et les raisons à l'origine de tous

1 Information financière des universités et collèges 2011-2012 ([www.caubo.ca/sites/137.149.200.5.pilot/files/ACPAU\\_INFORMATION\\_FINANCIERE\\_DES\\_UNIVERSITES\\_ET\\_COLLEGES\\_2011-2012.pdf](http://www.caubo.ca/sites/137.149.200.5.pilot/files/ACPAU_INFORMATION_FINANCIERE_DES_UNIVERSITES_ET_COLLEGES_2011-2012.pdf))

2 CAUT Almanac of Post-secondary Education in Canada / Almanach de l'enseignement postsecondaire au Canada de l'ACPPU ([www.caut.ca/docs/default-source/almanac/almanac\\_2013-2014\\_print\\_final.pdf](http://www.caut.ca/docs/default-source/almanac/almanac_2013-2014_print_final.pdf))

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## Letters to the Editors

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

## Lettres aux Rédacteurs

Les rédacteurs des NOTES acceptent les lettres en français ou anglais portant sur un sujet d'intérêt mathématique, mais ils se réservent le droit de les compresser. 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](mailto:notes-lettres@smc.math.ca).

### NOTES DE LA SMC

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

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

### CMS NOTES

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The Editors welcome articles, letters and announcements, which can be sent to the CMS Notes at the address below.

No responsibility for the views expressed by authors is assumed by the CMS Notes, the editors or the CMS.

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## *Vice-President's Notes, continued from cover*

My interpretation of NSERC's comments to me is the following: NSERC must provide evidence that the projects that they are funding have a direct impact on the general well-being and growth of the nation.

After every NSERC presentation, I am sure we all feel like we bitterly complain about the lack of dollars for fundamental research. Why is the government targeting more and more funds to specific areas? It seems to me it is to fund the government's identified strategic research investments, for example: the North, and increased University-Industry collaborations. One can't help but notice that some of these strategic research investments align quite nicely with the vision of the nation as a whole.

Over my career as an academic I have also had many opportunities to speak with federal members of Parliament, Senators, and provincial members of the Legislature as well as the various civil servants serving these individuals. In all cases, it was made very clear that the academic community is not doing a good job in promoting the importance of having a higher education system that needs to be heavily subsidized by the various levels of government. Indeed, in a very recent conversation I had with the top aide to a federal minister, he clearly stated that he would prefer to fund more training opportunities for pipe-fitters than to give additional support for the University sector. This is the reality, folks.

Further, while the percentage of government funding for University operating costs has decreased substantially over the years, the percentage of University operating costs paid by the students has increased. Hence from time to time, though not as often, undergraduate students question why their tuition is being used by faculty "not to improve their teaching" but to do research on some esoteric subject area that does not benefit the students directly. Again, the academic community is not doing a good job in showing how research informs teaching.

Now the group who knows best how to present our case is ourselves. I believe we, the CMS, as a subset of a larger academic community, have a lot of work to do.

I would like to propose one idea to start the conversation and to perhaps help us in our self-reflection. The Ivory Towers must come down. We need to engage more with our local communities. What are the problems that they need to have solved and what can we do to help them? Sure, this is biased perhaps towards applied mathematics, but as we work on these various problems, we have an opportunity to inform and educate the general public that what is now considered applied mathematics was once pure or fundamental mathematics. We need to inform the community that one is now using fundamental research which in fact may not have had directly attributable and tangible output when it was first conceived to solve a current problem.

Of course I cannot ask you to do something that I cannot do myself. I am only trying to raise awareness within the community that we must take steps to impress upon the general public the essentiality of our work, and that it does indeed provide tangible outputs for the betterment of Canadian society as a whole.

## *Vice-President's Notes, continued from cover*

les changements qu'ils effectuent depuis cinq à huit ans. J'ai appris que même si les gens sur le terrain au CRSNG comprennent la valeur actuelle et future de la recherche fondamentale, ils ressentent aussi de plus en plus vivement le besoin et l'obligation de rendre des comptes au public.

J'interprète ces commentaires de la façon suivante : le CRSNG doit prouver que les projets qu'il finance ont un impact direct sur le mieux-être et la croissance de la nation en général.

Après chaque présentation du CRSNG, je suis certain que nous avons tous l'impression de nous plaindre amèrement du manque de financement pour la recherche fondamentale. Pourquoi le gouvernement destine-t-il toujours plus de fonds à des secteurs précis? Sans doute pour soutenir ses domaines d'investissement stratégique, comme le Nord et la collaboration entre l'université et l'industrie. Difficile de ne pas remarquer à quel point certains de ces investissements semblent correspondre étroitement à une vision particulière de la nation.

Pendant ma carrière universitaire, j'ai aussi eu la chance de m'entretenir à maintes reprises avec des députés fédéraux et provinciaux, des sénateurs et les fonctionnaires au service de ces personnes. Chaque fois, il était évident que le milieu universitaire n'avait pas réussi à faire valoir l'importance d'un système d'enseignement supérieur fortement subventionné par les divers paliers de gouvernement. Très récemment, le plus proche collaborateur d'un ministre fédéral m'a même clairement indiqué qu'il aimerait mieux appuyer la formation des poseurs de tuyaux que d'offrir plus de financement aux universités. C'est là que nous en sommes, les amis.

Par ailleurs, on sait que dans les universités, la part des coûts de fonctionnement assumée par le gouvernement a beaucoup diminué ces dernières années, mais que celle couverte par les étudiants a augmenté. Par conséquent, même si ce n'est pas aussi fréquent, on entend aussi des étudiants de premier cycle demander de temps à autre pourquoi leurs droits de scolarité serviraient à financer des recherches sur des sujets obscurs sans retombées directes pour eux au lieu d'être investis dans la qualité de l'enseignement. Ici encore, le milieu universitaire n'a pas suffisamment montré le lien entre la recherche et l'enseignement.

Qui sont les mieux placés pour défendre nos intérêts? Nous-mêmes. Il me semble qu'en tant que membres de la SMC, sous-ensemble de la grande communauté de recherche, nous devons nous retrousser les manches.

J'aimerais proposer une idée pour amorcer la conversation et nous aider dans notre autoréflexion : il faut détruire la tour d'ivoire et travailler davantage avec les collectivités. Quels sont les problèmes qu'elles cherchent à régler et comment pouvons-nous leur prêter main-forte? Cette approche, qui peut bien sûr sembler favoriser les mathématiques appliquées, nous donnera la chance d'expliquer au grand public que les mathématiques appliquées sont le fruit de la recherche fondamentale. Nous devons mettre en valeur le fait que des connaissances qui servent maintenant à résoudre un problème n'avaient peut-être pas d'applications directes et concrètes lorsque la recherche fondamentale les a mises au jour.

Bien sûr, je ne peux pas vous demander de faire quelque chose dont je suis moi-même incapable. J'essaie simplement de faire valoir l'idée que nous devons trouver des façons de montrer au grand public à quel point notre travail est essentiel et profite concrètement à la société canadienne dans son ensemble.

	1	2	3							6	7	8	9	10			10	11	12	13	14
	8	9	10		1	2	3	4	5	6	7				13	14	15	16	17	18	19
4	15	16	17		8	9	10	11	12	13	14				20	21	22	23	24	25	26

**MARCH** 2014

## 28 PIMS/UBC Distinguished Colloquium: Linda Petzold

(University of British Columbia) <http://www.pims.math.ca/>

**28** 10:00-11:00 **Seminar Géométrie et topologie/Geometry-Topology** (UQAM, Pavillon Président-Kennedy, 201, ave. du Président Kennedy, salle PK-5115) Dan Popovich, U. Toulouse [http://www.cirget.uqam.ca/pages/activ/seminaires\\_fr.shtml](http://www.cirget.uqam.ca/pages/activ/seminaires_fr.shtml)

**28 14:00 Introductory Lectures on Spectral Synthesis, Ideals and Homomorphisms** Eberhard Kaniuth (Paderborn) (*Fields Institute, Stewart Library*)

**28 15:30-16:30 Seminar Statistique McGill** (*McGill University, Burnside Hall, Room 1205*) **How much does the dependence structure matter?** Ruodu Wang, University of Waterloo  
<http://www.math.mcgill.ca/node/5358>

**28 18:00-20:00 Distinguished Lecture Series in Comp. Sci. / Software Engineering** (EV 1.605 (1515 Ste. Catherine West) Concordia University) **Randomness** Avi Wigderson, Princeton University  
<http://www.cs.concordia.ca/documents/other%20documents/promo-Randomness%20Final%20Web.pdf>

**29 10:00-17:00 Nouvelles avenues en théorie de Lie** (*CRM, Université de Montréal, Pavillon Aisenstadt, salle 4336-4384*) **Learning seminar on Kac-Moody algebras** <http://www.crm.math.ca/TheorieLie2014>

**30-April 4 Specialization of Linear Series for Algebraic and Tropical Curves** <http://www.birs.ca/events/2014/5-day-workshops/14w5133>

**30-April 6** On a system of hyperbolic balance laws arising from chemotaxis <http://www.birs.ca/events/2014/research-in-teams/14rit198>

**31 10:00 Introductory Lectures on Fourier and Fourier-Stieltjes Algebras, and their Operator Space Structure** Nico Spronk (*University of Waterloo*) *Fields Institute, Room 230*

## APRIL 2014

**1 10:00 Introductory Lectures on Approximation Properties for Group C\*-Algebras** Narutaka Ozawa (RIMS, Kyoto)  
*Fields Institute, Room 230*

**2 Sun Life Financial Canadian Mathematical Olympiad**  
<http://cms.math.ca/Competitions/CMO/>

**4 An afternoon in honor of Cora Sadosky** (*Albuquerque, New Mexico*) <http://www.math.unm.edu/conferences/13thAnalysis/>

**4 16:00 Quantum Algebra Seminar** *Fields Institute, Stewart Library*

**APRIL 2014 (CONTINUED)**

## 5 Math in Motion...Girls in Gear *(Fields Institute)*

**6-11 Complex Monge-Ampère Equations on Compact Kähler Manifolds** <http://www.birs.ca/events/2014/5-day-workshops/14w5033>

**6-13 Subfactors, Twisted Equivariant K-theory and Conformal Field Theory** <http://www.birs.ca/events/2014/research-in-teams/14rit179>

**7 PIMS Marsden Memorial Lecture: Mathieu Desbrun**  
(Instituto Nacional de Matematica Pura e Aplicada (IMPA), Rio de Janeiro)  
<http://www.pims.math.ca/scientific-event/140526-nlbp>

**7 CRM-Fields-PIMS Prize Lecture: Niky Kamran**  
(University of British Columbia)  
<http://www.pims.math.ca/scientific-event/140407-cfpplnk>

**7-11 Tools from Algebraic Geometry** (*Los Angeles, CA*)  
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## MAY 2014

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**1-4 Canadian Mathematics Education Forum (CMEF)**  
[cms.math.ca/Events/CMEF2014](http://cms.math.ca/Events/CMEF2014)

*continued on page 20*

## Past and Present in Mathematics: Notes from the CSHPM

Tom Archibald, *Simon Fraser University*

### Mediæval and Renaissance Algebra

These columns, originating with the Canadian Society for History and Philosophy of Mathematics, are intended to make *CMS Notes* readers a little more aware of research in the history of mathematics. Various approaches will be taken to this project, but in this case I thought it would be useful to draw the attention of a larger audience to recent work on the history of mathematics in mediæval and renaissance Europe. I was stimulated in the choice of topic by the recent award of the K. O. May Prizes and Medals in the history of mathematics (see <http://www.unizar.es/ichm/maymedal.html>) to two distinguished researchers whose activity touches on this period: Menso Folkerts of the University of Munich, and Jens Høyrup from Roskilde University. This is not a scholarly article, so referencing will be sloppy; and the point of view is mine alone, and doubtless very liable to criticism by serious scholars of this period.

Let's begin with the passage of Hindu-Arabic numerals and algebra to Europe. This is associated with the well-known name of Fibonacci, Leonardo Pisano, whose *Liber abbaci* first appeared in 1202. This work was translated into English by L. E. Sigler, and published in 2002. The term *abbaco* of the title refers not to the familiar abacus but rather to the practice of calculation. A key feature of the work is its introduction of what are now our usual numerals to the Latin-reading "public." Who that public was remains difficult to know, though 12 manuscripts survive, three of them complete (this is a rather large number, indicating a certain popularity). Fibonacci was associated with the emperor Frederick II, founder of the University of Naples, though the work itself was dedicated to Michael Scot (or Scotus), who according to Dante wound up in hell:

Quell' altro che ne' fianchi è così poco,  
Michele Scotto fu, che veramente  
de le magiche frode seppe 'l gioco.

Perhaps Leonardo avoided such games of magical deceit and avoided this fate (damnation, that is: the skinny flanks are less worrisome). Michael would at least have looked at Leonardo's work, no doubt. However, such a detailed treatise would mostly be of use to those who wanted to learn the contents thoroughly. These contents include the algorithms for calculating with the Hindu-Arabic numerals and their applications, and they were at the very least of interest to those who wanted to make a living with them, for example by teaching calculations. There is also an algebraic portion to the *Liber abbaci*, and we return to it below, where interestingly the proofs are based on Euclid, Book Two.

These circumstances seem to have created a demand for works in the vernaculars of the northern Mediterranean: not only the various languages of the Italian peninsula, but Provençal, Catalan, and so forth. There is a constellation of such works, though the record is

fragmentary, and there are natural questions about the relationships among the various surviving texts. In the context of algebra, we have a very nice recent survey article by Raffaella Franci, in [Franci 2010]. She points out that until the work of Pietro Cossali around 1800 it was generally thought that Fibonacci was a century later, and no one noticed his algebra chapter. Algebra in Italy was first examined in the work of Pacioli in the (very) late fifteenth century, though Pacioli himself acknowledged his debt to Fibonacci. It was Cossali who concluded that algebra came to Europe from Arabic sources via Fibonacci. A manuscript catalog compiled by W. van Egmond in 1980, and the many works of Franci herself and her colleague Laura Tota Rigatelli, provide the foundation for what we now know about the history of algebra in Italy leading up to the solution of the cubic. This is a long story, full of rules both right and wrong, and it reminds us, if we needed reminding, that mathematics is hard and that notation is crucial.

As for the subcategory of algebras in the vernacular, here we have a controversy concerning which was the first such work. This has more historical interest than some firsts do, since it may be relevant to the history of the transmission of the technology. In 1978, Van Egmond identified Paolo Gherardi's 1328 chapter in his *Libro di ragioni* as having this status. This work, written in Montpellier a century and a quarter later than the Latin manuscript of Fibonacci, differs from the latter in various respects, notably in the absence of geometric proofs and the introduction of problems having to do with interest calculations. More recently Høyrup has proposed another candidate, a 1307 work by Jacopo de Florentia, likewise produced in Montpellier in a version of Italian, as differing from Fibonacci and from Gherardi – and, significantly, also differing from Al-Khwarizmi. Gherardi's text contains some wrong rules, not in Jacopo's, which suggests different sources despite other resemblances. Høyrup argues for a common origin, not Arabic directly, but from a non-Italian source, possibly in the region where Catalan was spoken. This claim was contested by Jeff Oaks in a review appearing in the CSHPM *Bulletin* (which you can receive by joining, see <http://www.cshpm.org>). Readers are invited to make up their own minds, by looking at [Høyrup 2007].

A further recent landmark in the scholarship of a slightly later period is a new edition of Girolamo Cardano's *Artis Magna* by Massimo Tamborini. The "Great Art" was published in Nuremberg in 1545, and the original is not an easy read due to the use of abbreviations in the printed text. [Tamborini 2011] simplifies this, providing expanded readings and the usual healthy critical apparatus that goes along with a solid edition. The modern notation for the equations in the verbal text are found in an appendix, so you can test your skills: quick, write "numerus et cubus cubi aequalia cubo et cubo quadrati" as an equation, not forgetting to include arbitrary coefficients where warranted.

I'll conclude this survey of recent work of interest by mentioning not a single "research product" but a huge body of work by a researcher on the borders of our field, Charles Burnett. Burnett is the professor of the History of Islamic Influence in Europe at the

Warburg Institute, University of London. As a tantalizing title I will mention 'Indian Numerals in the Mediterranean Basin in the Twelfth Century, with Special Reference to the "Eastern Forms"', to be found in the collection [Dold-Samplonius 2002, pp. 238-288]. This is one of over 200 articles on the author's website, <http://warburg.sas.ac.uk/index.php?id=424>, and we note the presence of the May Medallist Folkerts' name among the distinguished list of editors.

## Some Works Discussed in the Text

[Dold-Samplonius 2002] *From China to Paris: 2000 Years' Transmission of Mathematical Ideas*, eds Y. Dold-Samplonius, J. W. Dauben, M. Folkerts and B. van Dalen, Stuttgart: Steiner.

[Franci 2010] Franci, Raffaella, "The History of Algebra in Italy in the 14<sup>th</sup> and 15<sup>th</sup> Centuries. Some Remarks on Recent Historiography," *Actes d'histoire de la ciència i de la tècnica*, Nova Epoca 3(2), 175-194 (See <http://schct.iec.cat/>).

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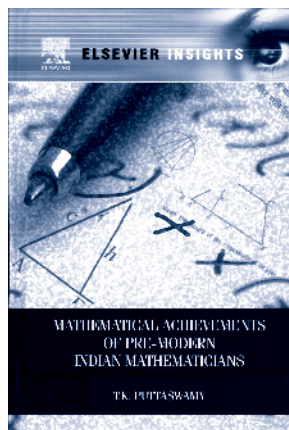
## Mathematical Achievements of Pre-Modern Indian Mathematics

by T. K. Puttaswamy

Elsevier Insights, 2012

ISBN 978-0-12-397913-1

Reviewed by **S. Swaminathan**, Dalhousie University, Halifax, N. S.



It is said that Bertrand Russell used to welcome every visiting Indian dignitary with the statement "The greatest contribution of India to mathematics is zero." The consequent discomfiture of the guest was allayed by Russell by saying that he meant the invention of the concept of '0'.

"It is high time that the full story of Indian mathematics from Vedic times through 1600 became generally known," writes David Mumford in his review of *Mathematics in India*

by Kim Plofker [Notices of AMS, March 2010, 385-390].

The book under review presents such a story in 735 pages. It draws attention to the historical continuity of the development of mathematics in India, from the Sulba-sutras (the rules of the cord) of the Vedic period, describing the evolution of contributions up to the seventeenth century. No comparison is made with Greek mathematics or that of other cultures. The present author has contributed an article on this subject to the book *Mathematics across Cultures* (Kluwer Academic Publishers) in 2000. The subject is treated chronologically covering contributions in Algebra, Geometry, and Hindu Trigonometry. As mentioned in the Preface, the prominent features of the book are detailed proofs, adequate illustrative examples, mathematical explanations, and critical observations.

Original Sanskrit verses are quoted in Devanagari script, with appropriate translations.

The most important mathematical contribution of ancient India is the invention of the decimal system of numeration, including the number zero. This fact is discussed in the first chapter. Interesting quotations from various authors are given at appropriate places throughout the book. For example the following remark of G. B. Halsted appears in the first chapter: "The importance of the creation of the zero mark can never be exaggerated. This gives to airy nothing not merely a local habitation and a name, a picture, a symbol but helpful power is the characteristic of the Hindu race whence it sprang. It is like coining the Nirvana into Dynamics. No single mathematical creation has been more potent for the general on-go of intelligence and power."

The Pythagoras theorem is forestalled in "Baudhayana Sulvasutra" in the form that 'the diagonal of a rectangle gives an area equal to the sum of the areas given by its length and breadth.' The Vedic authors did not prove the theorem, nor did Pythagoras himself!

The topics in the remaining chapters of the book are treated in a similar manner with explanations of Sanskrit quotations, proofs of results, and interesting commentaries. The chapter headings are: The Sulvasutras, Mathematics of Jains, The Bakshali Manuscript, Aryabhata I, Varahamira and Bhaskara I, Brahmagupta, Sridhara and Prthudakaswami Caturveda, Mahavira, Aryabhata II and Sripati, Bhaskara II, Narayana Pandita, Kerala Astronomers, and Sixteenth and Seventeenth Century Commentators of Bhaskara II, Appendix, Bibliography.

As pointed out in the Foreward by U. D'Ambrosio (São Paulo), the book gives the reader an overall idea of the contributions of ancient authors to the development of Indian mathematics, which will be helpful for students and researchers working on specific authors and topics in Indian mathematics.

The excellent treatment of the topics in the book is marred by poor proof correction.

The Bibliography contains 163 items; a comprehensive one, but marred by misquotations of the bibliography numbers in the text. Hopefully these lapses would be remedied in the next edition of the book.



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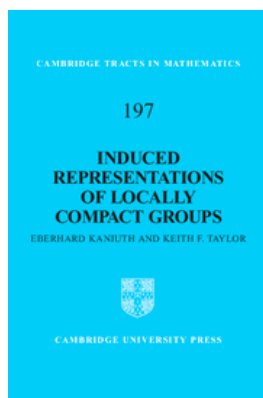
## Induced Representations of Locally Compact Groups

by Eberhard Kaniuth and Keith Taylor

Cambridge University Press 2013

ISBN 978-0-521-76226-7

Reviewed by **V. S. Varadarajan**, University of California at Los Angeles



This book deals with the theory of induced representations of locally compact groups. The theory, originally created by Frobenius in the last years of the nineteenth century, was extended by George Mackey to the category of all separable locally compact groups. Later work showed that separability was unnecessary. In what follows we shall speak of only locally compact groups and so omit the reference to locally compact.

In this context Mackey showed that if  $H$  is a closed subgroup of  $G$ , the method of inducing gives rise to a functor from the category of unitary representations of  $H$  to the category of unitary representations of  $G$ . The generality of the context made it difficult to generalize all aspects of the work of Frobenius, but Mackey did a fair amount, like the Frobenius reciprocity theorem, restriction to subgroup theorem, and so on. But Mackey went beyond Frobenius in showing that if  $H$  is normal in  $G$ , one can get a substantial insight into  $\hat{G}$ , the unitary dual of  $G$ , from a knowledge of  $\hat{H}$  and the way  $G$  acts on  $\hat{H}$  (derived from the action of  $G$  on  $H$  via inner

automorphisms). Later Kirillov showed that for nilpotent Lie groups  $G$  one can get a direct hold of  $\hat{G}$ . But in treating these questions in the full category of locally compact groups, it is important to think  $\hat{G}$  as something more than a set, and this is where the Fell topology of  $\hat{G}$  comes into play.

The book by the authors gives a careful presentation of these results. Special results when  $G$  and  $H$  are specialized (such as when  $H$  is abelian) are discussed in detail. For a beginner who is interested in knowing this theory this is very useful.

Unfortunately the authors did not take the opportunity of connecting this theory with what is going on in other parts of mathematics, thereby reducing its usefulness to the young and aspiring reader. In particular no connection with Lie groups is discussed, which is a pity since it was Bruhat's ideas that made great progress beyond Mackey (to get the intertwining number formula for example, something that cannot be done in the category of all locally compact groups where only Hilbert techniques can be used). Also no mention is made of property  $T$ , and the spectacular application of it made by Kazhdan to the problem of finite generation of discrete subgroups of Lie groups, and the progress made thereafter by Pierre de la Harpe and others. The importance of going beyond Lie groups was revealed only when Artin applied Fourier analysis on the Adele groups to reveal its number-theoretic significance, and then, going beyond in a fantastic leap, when first Harish-Chandra, and later decisively, Langland showed how the unitary representation theory of the Adele groups of algebraic semi simple groups has a deep interaction with modern number theory. The reader of this book will have no inkling of these explosive developments in the past 50 years because the book envelopes him/her in a sound-proof cocoon.

## CMS Member Profile

### Dr. Edgar G. Goodaire

**HOME** Memorial University, St. John's, Newfoundland

**RESEARCH** Primarily within the field of nonassociative algebra; especially loops which are Moufang or Bol, and rings which are alternative or right alternative.

**DISTINCTION** Science Atlantic Hall of Fame 2013; CMS Distinguished Service Award 2004

**HOBBIES** I inherited a great love of the arts from my parents and especially classical music. For a number of years, I played violin with the Newfoundland Symphony Orchestra.

**PROFESSION** Honorary Research Professor

**LAST BOOK READ** Two volumes about Sir John A. Macdonald and the beginnings of Canada, by Richard Gwyn. Terrific reading.

**LATEST ACCOMPLISHMENT** Author of "Linear Algebra: Pure and Applied," <http://www.worldscientific.com/worldscibooks/10.1142/8808> published by World Scientific in 2014.

**CMS INVOLVEMENT** Lifetime Member; Board of Directors; Vice-President; Treasurer; and Chair of various CMS committees.



**WHY I CHOOSE CMS** The UBC math department, where I was a graduate student, introduced me to the CMS and gave me my first membership in 1970. It has never occurred to me not to be a member. It's our national society!

It supports what we do and who we are.

**Jennifer Hyndman**, *University of Northern British Columbia*  
**John McLoughlin**, *University of New Brunswick*

*Submissions from people in the mathematical community, whether solicited or not, give rise to the shape of Education Notes. The editors welcome contributions that can be sent directly to John (johnngm@unb.ca) or Jennifer (hyndman@unbc.ca). One such contribution was recently received from Patrick Reynolds. His thoughts on language and mathematics are featured in this issue. The ideas prompted Jennifer Hyndman to articulate some of her musings on the subject. The two pieces appear here. Comments and feedback are welcome.*

## Catchphrases and Idioms in Mathematics Instruction

**Patrick Reynolds**, *University of New Brunswick*  
(p.reynolds@unb.ca)

Perhaps you've encountered, in one form or another, the following mistake:

$$\frac{d}{dx}a^x = xa^{x-1}$$

This, of course, is a misapplication of the ambiguously named "Power Rule" for differentiating functions of the form  $f(x) = x^n$ ,  $n \neq 0$ . This Power Rule, applied ad nauseum in any first year calculus course, often comes with its very own catchphrase: "bring the exponent down and subtract one" or some similar verbalization of the process. What role, if any, does this catchphrase play in the proliferation of the above mistake?

When I teach the Power Rule, I take what I think is considerable care to point out that it applies only when the base is the independent variable and the exponent is a non-zero constant. I reiterate this point later in the term when we differentiate exponential functions. Hence my dismay at finding the above mistake more than a few times on final exam papers. I dug out my lecture notes, and took comfort when I found the page where I highlighted how the Power Rule doesn't apply to exponential functions; I'm certain, however, that in many instances where I applied the Power Rule in lecture I uttered something like "bring the exponent down and subtract one", no doubt feeling that this informal play-by-play commentary of the calculations was very helpful to the students. And so I wondered, what if I had never said anything to the effect of bringing the exponent down? Is there any possibility that fewer students would make the above mistake? Or would some variation of the Power Rule catchphrase manifest itself in a student's mind anyhow (it does sum up what one writes on the page, after all), thus leading to the same mistake regardless of what I say?

These questions prompted me to investigate the use of language in math instruction more generally. Now, I'm a mathematician with a growing interest in math education, and I suspect that anything I say in these notes has been more thoroughly studied and better articulated elsewhere. My hope is to start a conversation with fellow mathematicians and educators, to discuss what is known about where and when informal language helps or hinders learning, and to perhaps build upon that knowledge. Informal language is used extensively in the demonstration of mathematical problem-solving. The narration of algebraic manipulations can be a mélange of "bring-it-over"s, "bring-it-up/down"s, "pull-it-out-in-front"s, and "cancel-out"s. Until recently I took it for granted that these phrasings are completely natural and helpful to almost anyone learning mathematics. That may well be the case for some such phrases; at this point I am not equipped to make a case either way. But I've witnessed enough confusion over the use of the word "cancel" for instance, to convince me that informal phrasing of specific operations can be troublesome. In the words of R.P. Boas [1], "It is especially dangerous to assume either that the audience understands your vocabulary already or that the words mean the same to everybody else that they do to you."

Beyond the contentious use of mnemonic devices (e.g. FOIL, or is it OLIF?) and other cutesy phrases (e.g. "to have a positive experience, negative exponents must move upstairs"; huh?), the language we use to teach mathematics is often mechanistic and kinematic. We are agents of change, acting upon symbols, moving things around. This seems natural enough, and interestingly, there is research to suggest that body movements can aid retention; students who recited a catchphrase accompanied by a suitable physical gesture retained more information than those who recited the phrase without the gesture [2]. (Of course, the choice of *which* gesture should probably not be left up to a frustrated and over-stressed student who hates mathematics and is keen to say so.)

There is also research concluding that even minor changes in our language can significantly impact understanding. For instance,



vocalizing  $\frac{3}{4}$  as “three fourths” encourages a deeper understanding of fractions than does “three out of four” [3]. Because the latter phrase relates all fractions to whole numbers, a student visualizes four objects and taking three of them rather than one whole partitioned into equal fourths. This thought process makes the ever-aggravating mistake

$$\frac{a}{b} + \frac{c}{d} = \frac{a+c}{b+d}$$

much more understandable; selecting  $a$  of  $b$  objects and  $c$  of  $d$  objects results in a total selection of  $a + c$  out of  $b + d$  objects. (Once again I feel obliged to state my naïveté in these matters: perhaps this is old hat to the math ed community, but I’d never thought about it before and find it comforting that there is some basis for that pernicious mistake.)

What, then, about all of the “bring-it-over” language? Might there be subtle misunderstandings that arise, perhaps even about whether the left-hand-side is more or less important than the right-hand-side of equations? I’ve found, to my dismay, that sometimes all it takes to cause confusion is to reverse the order in which I write down a previously written equality, and sometimes it seems even the notion of equality itself is ripe for misunderstanding. And after a perusal of a collaborative effort [4] among math educators to replace “tricks” with more rigorous explanations, I’ve tried to stop using the word “cancel” so frequently. I’ve found it more effective to write the extra step wherein  $a/a = 1$  or  $b - b = 0$ . Are other words and phrases worth reviewing?

I would be happy to hear from anyone who can suggest references or who would like to engage in a conversation about the role of informal language in mathematics instruction.

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## Speaking Mathematics Accurately: Do we do it?

Jennifer Hyndman,  
*University of Northern British Columbia*

The article by Patrick Reynolds prompted me to think about language in the classroom and what we are really doing. My past experiences with dictation in the classroom (see CMS Notes Volume 41, No. 6, p. 10-13) mean I know that the students literally do not hear what we are clearly saying. But what are we doing to them when we are inaccurate or vague in our language? Inherently mathematics is about definitions and axioms and proofs that follow from applications of logic. Yet we blur our definitions, wave our hands over proofs and use intuition to convince students that things are true. Should we be teaching first year classes that are about definitions and what happens when one makes tiny changes in the definitions? Should we stop asking our classes to simply accept on faith various theorems because we cannot actually explain to them a proof. What would happen to their understanding of mathematics if we took the time to chew over, regurgitate, rework, redo, and simplify proofs that students created?

I have had the opportunity to see some students in upwards of five or more courses over their undergraduate and graduate careers, and I am fascinated by the level of mathematical maturity that changes over this time. A big part of this maturity is in their questions. It feels like they develop the ability to get to the meat of the ideas but I suspect it is that they are developing an understanding of subtlety of language.

An example of language blurring that I see in first year is that of the concept of a function. We carefully say that a function is a rule that takes one input and gives one output (or some similar definition) and then we talk about the function  $x^3 + 4x - 7$  or the function  $f(x)$ . **Maple** and a Computer Science colleague of mine taught me that this is vague. **Maple** requires one to distinguish between a function  $x \rightarrow x^3 + 4x - 7$  and an expression  $x^3 + 4x - 7$ . The students initially struggle with **Maple** because they do not know that there is a difference between a function with name  $f$  and an expression  $f(x)$  that is the output of putting  $x$  into the function. They eventually understand that for talking to the computer there are two forms and that it matters which they use. This knowledge does not easily transfer to hand-written work for derivatives of complicated functions. I think that this is exacerbated by us as teachers not consistently *speaking* the difference. We “all know what we mean” when we use an expression in place of a function. Alas, the students haven’t internalized the difference so that they cannot know which to think about.

For me, despite my desperate attempts to clearly speak mathematics, my students struggle with composition of functions and repeated use of the chain rule. Students read out loud  $\sin(\tan(x^3 + 4x - 7))$  as “sine tan  $x$  cubed plus four  $x$  minus seven”. There is no verbal acknowledgment that this is composition of functions. Or they read it as “sine times tan  $x$  cubed plus four  $x$  minus seven” which explicitly acknowledges that they are seeing composition as multiplication. In recent years I have taken to writing down how I read it so that they can



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see the words that indicate composition of functions. “Sine OF tan OF  $x$  cubed plus four  $x$  minus seven”. The students that learn to hear and say the “OF” for composition appear to have much higher success rates in doing derivatives of complicated functions. In a class of 100 students they find speaking quite intimidating but I often get them to do choral recitation and by the time we have gotten to derivatives of composition, they expect me to call on someone to read material out loud.

Another place that students fail to meet my expectations occurs when they use strings of equations or rather strings of expressions with equal signs freely scattered about. We have all seen the version of *Solve*  $x^2 + 10 = 5x + 4$  that goes

$$\begin{aligned} & x^2 + 10 = 5x + 4 \\ = & x^2 + 6 = 5x \\ = & x^2 - 5x + 6 = 0 \\ = & (x - 2)(x - 3) = 0 \\ & 2, 3. \end{aligned}$$

The equal signs on the left are incorrect. I have always told my students that they are lying to me when they put equal signs between things that are not equal. They hear that but do not always know what the lie is. I have recently attended a number of presentations about teaching First Nations students. One of the key ideas that I took out of these was the idea of story. Our mathematical stories are full of abbreviations and short cuts. We need to teach our students to be verbose story tellers and, as they develop mathematical maturity, they can leave out the unnecessary details. I am so excited when I get a solution that actually uses words, such as, *In order to solve  $x^2 + 10 = 5x + 4$  we first need to bring all terms to the left side.*

$$\begin{aligned} x^2 + 10 &= 5x + 4 \\ x^2 + 6 &= 5x \\ x^2 - 5x + 6 &= 0 \end{aligned}$$

*We now need to factor the quadratic on the left. We could use the quadratic equation but this one can be factored by inspection.*

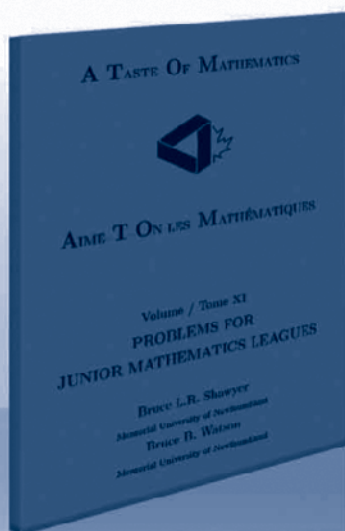
$$\begin{aligned} (x - 2)(x - 3) &= 0 \\ x &= 2 \text{ or } x = 3 \end{aligned}$$

*There are two possible solutions  $x = 2$  or  $x = 3$ . This tells the story of what the student does to get the answer.*

What is it that we are doing that leads them to the misuse of equal signs? That they do not tell the story is clearly our doing as we do not reward students for writing words and, in fact, we penalize them by having tests that are too long for the students to answer in the given time. However, when students are encouraged to write in this way, they are learning the language to effectively communicate mathematics.

In universal algebra we use two symbols “=” and “ $\approx$ ”. The first symbol denotes that the surrounding expressions have identical values. The second symbol denotes that for all possible substitutions the expressions are the same. Thus I would write  $x^2 - 5x + 6 = 0$  when I am talking about the particular  $x$  value that makes the expression  $x^2 - 5x + 6$  evaluate to 0 (existential quantification). When I write  $x^2 - 5x + 6 \approx (x - 2)(x - 3)$  I mean that this is true no matter what value of  $x$  is substituted in (universal quantification). Would making this distinction for first year students help them? When I first introduce this distinction to fourth year students they are initially confused and then realize that, indeed, there are two concepts. They don’t always choose the correct symbol to write but I believe that habit is part of the reason for their continued use of = when they should be using  $\approx$ .

I think that we would create better mathematicians, better students, and better people if we accurately used language and taught our students to tell the mathematical stories. What can we do to help them? We can accurately use language; point out when our textbooks blur concepts; give tests that have questions specifically about mathematical language; and keep the students talking mathematics. Maybe then our students would be less confused and better able to learn the content.



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## Statistical Modeling of Electromagnetic Neuroimaging Data

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Recent advances in the speed and accuracy of data acquisition through modern neuroimaging tools, such as functional magnetic resonance imaging (fMRI), positron emission tomography (PET), electroencephalography (EEG), and magnetoencephalography (MEG), allow unprecedented opportunities for understanding brain function in health and disease. The statistical analysis of the resulting data is crucial for improving our understanding of the human brain. In this note we describe our recent work developing methodology for electromagnetic brain imaging data collected using MEG and EEG. With an array of external sensors, MEG and EEG measure, respectively, the magnetic fields and electric potentials generated by small intracellular currents in neurons of the brain. Here, the electrical neural activity *within the brain* is measured indirectly through the associated electromagnetic field at sensors located *outside the scalp*. For a single subject, we obtain a multivariate time series  $\mathbf{Y}(t) = (Y_1(t), \dots, Y_{n_s}(t))'$ ,  $t = 1, \dots, T$ , where  $Y_j(t)$  is the observation at time  $t$  measured at the  $j^{\text{th}}$  sensor,  $j = 1, \dots, n_s$ . In a typical study, data are obtained from multiple subjects, each belonging to a well defined group. The goal is then to characterize how the groups differ with respect to the patterns of brain activity in either the spatial, temporal, or frequency domains, or in the topology of underlying connectivity networks.

The analysis can proceed directly at the level of the MEG/EEG sensors, or alternatively, at the level of the actual neural sources within the brain. A sensor level analysis is more straightforward as there is no need to map the data from sensors to sources. In this case, the scalp is partitioned into several regions each comprising a small number of adjacent sensors, and each region corresponds roughly to a particular area of the brain. In contrast, a source level analysis proceeds by first taking the data for each subject and mapping it back to the corresponding locations within the brain in order to estimate the neural activity. The relationship between the observed data and the unknown neural activity is governed by Maxwell's equations, and like many other inverse problems in physics, that of neuromagnetism is ill-posed. In our recent work we have developed methods for sensor level analysis in group studies as well as Bayesian approaches to the inverse problem.

In [1] we develop a Bayesian sensor level approach for spectral analysis, where the frequency content of the data is summarized by computing the mean frequency of the power spectral density at each sensor location. Let  $U_{ijk}$  denote the log-mean-frequency at the  $k^{\text{th}}$  sensor within the  $j^{\text{th}}$  scalp region for subject  $i$ . To assess group differences we specify the *space-varying regression model*

$U_{ijk} = \beta_j' x_i + b_i + a_{ij} + \epsilon_{ijk}$ ,  $i = 1, \dots, s$ ;  $j = 1, \dots, r$ ;  $k = 1, \dots, m_j$ , where  $s$  is the number of subjects;  $r$  the number of regions;  $m_j$  the number of sensors in region  $j$ ;  $\mathbf{X}_i = (x_{i1}, \dots, x_{ip})'$  are explanatory variables;  $\beta_j = (\beta_{j1}, \dots, \beta_{jp})'$  are regression parameters;  $b_i | \sigma_b^2 \stackrel{iid}{\sim} N(0, \sigma_b^2)$  and  $a_{ij} | \sigma_a^2 \stackrel{iid}{\sim} N(0, \sigma_a^2)$  are random effects accommodating correlation structure;  $\epsilon_{ijk} | \mu, \sigma_\epsilon, \alpha, \nu \stackrel{iid}{\sim} St(\mu, \sigma_\epsilon^2, \alpha, \nu)$  are the regression model errors. Unlike a standard regression model, the regression parameters  $\beta = (\beta_1, \dots, \beta_r)'$  in this model vary spatially over the scalp regions, and these coefficients are assigned a Gaussian Markov random field prior which encourages spatial smoothing in the coefficients of neighboring regions. In applications to real MEG data, we have found that a Gaussian distribution for the errors  $\epsilon_{ijk}$  results in a poor fit. Typically, the residuals from such a model will exhibit skewness and a power-law tail behaviour. The skew-t distribution, denoted as  $St(\mu, \sigma^2, \alpha, \nu)$  (see e.g., [2]), is a four-parameter generalization of the Gaussian distribution that provides a much better fit to empirical data.

Inference on the regression parameters is based on the posterior distribution  $P(\beta | \{U_{ijk}\})$ , which is analytically intractable and is approximated using Markov chain Monte Carlo (MCMC). Implementation is made difficult by the rather complex form of the skew-t error distribution. We have developed an approach based on a stochastic representation of the skew-t distribution, where  $Y \sim St(\mu, \sigma^2, \alpha, \nu)$  can be expressed using a three-stage hierarchical representation based on latent variables  $Z$  and  $W$ , where  $Y | Z, W \sim N(\mu + \frac{\alpha Z}{\sqrt{1 + \alpha^2}}, \frac{\sigma^2}{W(1 + \alpha^2)})$ ,  $Z | W \sim TN_{(0, \infty)}(0, W^{-1})$ , with  $TN_{(0, \infty)}(0, W^{-1})$  denoting a  $N(0, W^{-1})$  distribution truncated to  $(0, \infty)$ , and  $W \sim \text{Gamma}(\nu/2, \nu/2)$ . Using this representation, we compute the higher-dimensional posterior distribution  $P(\beta, \{Z_{ijk}\}, \{W_{ijk}\} | \{U_{ijk}\})$ , which actually simplifies the computation due to the representation based on standard distributions. As a result, we have been able to fit this model using off-the-shelf software. In [1] we apply this methodology to an MEG study comparing the resting state brain activity of individuals with and without Down syndrome (DS), where our analysis reveals spectral slowing in the brain activity of DS subjects in scalp regions associated with learning and memory.

In [3] we tackle the inverse problem of mapping MEG/EEG data back to the brain. Using magnetic resonance imaging, we begin by constructing a surface representation of the subject's cerebral cortex. This surface is tessellated with a triangular mesh, and a single source is assigned to each vertex so that sources of activity are distributed across a large number  $n_b$  of locations covering the cortex. Under the quasi-static approximation of Maxwell's equations, the relationship between the observed data  $\mathbf{Y}(t)$  and the unknown neural activity  $\mathbf{S}(t)$  can be represented by an *underdetermined* linear model  $\mathbf{Y}(t) = \mathbf{X}\mathbf{S}(t) + \epsilon(t)$ ,  $t = 1, \dots, T$ ,  $\epsilon(t) | \sigma^2 \stackrel{iid}{\sim} MVN(\mathbf{0}, \sigma^2 \mathbf{I})$ , where  $\mathbf{S}(t) = (S_1(t), \dots, S_{n_b}(t))'$  with the function  $S_j(t) \in \mathbb{R}$  representing the magnitude and

polarity of the electrical activity at the  $j^{th}$  brain location; and  $\epsilon(t) = (\epsilon_1(t), \dots, \epsilon_{n_s}(t))'$  is sensor noise. The  $n_s \times n_b$  matrix  $\mathbf{X}$  is pre-computed based on differential equations describing the propagation of electromagnetic waves away from the neural sources. Fitting the model is non-trivial as the number of sources is of the order  $n_b = 10,000$ , while there are only a few hundred sensors, so that  $n_b \gg n_s$  and regularization is required. Each signal is projected onto a known functional basis  $\mathbf{b}(t) = (b_1(t), \dots, b_m(t))'$  so that  $S_j(t) = \boldsymbol{\eta}_j' \mathbf{b}(t)$ ,  $j = 1, \dots, n_b$ , and regularization is based on assigning a 'spike-and-slab' prior  $\boldsymbol{\eta}_j | \mathbf{p}, \tau \stackrel{\text{ind}}{\sim} p_j MVN_m(\mathbf{0}, \tau \mathbf{I}) + (1 - p_j) \mathbf{1}_0(\boldsymbol{\eta}_j)$ ,  $j = 1, \dots, n_b$ , where  $\mathbf{p} = (p_1, \dots, p_{n_b})'$  with  $p_j$  being the probability of activation at brain location  $\mathbf{s}_j \in \mathbb{R}^3$ . The prior is a two-component mixture representing two hidden neuronal subpopulations, an excitatory subpopulation corresponding to the Gaussian component, and an inhibitory subpopulation represented by the point mass placed on the event  $\boldsymbol{\eta}_j = \mathbf{0}$ , corresponding to inactive locations where  $S_j(t) = 0$ . Variability in  $\mathbf{p}$  is represented through a logistic regression  $\log\left(\frac{p_j}{1-p_j}\right) = \sum_{l=1}^Q \omega_l F_j^{(l)} + \alpha_{\mathbf{s}_j}$ , where  $\alpha_{\mathbf{s}_j}$  is a spatial effect encouraging clustering in brain activation;  $\boldsymbol{\omega} = (\omega_1, \dots, \omega_Q)'$  are regression parameters that link the probability of activation to variables  $\mathbf{F}^{(l)} = (F_1^{(l)}, \dots, F_{n_b}^{(l)})'$ ,  $l = 1, \dots, Q$ , derived from fMRI data to inform the prior.

Conditioning on the observed data  $\mathbf{Y}$ , point and interval estimates of the neural activity are obtained from the posterior distribution  $P(\boldsymbol{\Theta} | \mathbf{Y})$  where  $\boldsymbol{\Theta} = \{\boldsymbol{\omega}, \{\boldsymbol{\eta}_j\}, \boldsymbol{\sigma}^2, \tau\}$ . While MCMC is the standard approach to approximating such a distribution, we have found that simulation-based methods are not practical for the problem at hand. The difficulty arises due to the dimension of  $\boldsymbol{\Theta}$  which can be upwards of 200,000.

As an alternative, we develop a deterministic variational approximation. We let  $q(\boldsymbol{\Theta})$  be any density having the same support as  $P(\boldsymbol{\Theta} | \mathbf{Y})$  and express  $\log P(\mathbf{Y}) = \log\{P(\boldsymbol{\Theta}, \mathbf{Y})/P(\boldsymbol{\Theta} | \mathbf{Y})\} = F + KL$ , where  $F = \int \log\{P(\boldsymbol{\Theta}, \mathbf{Y})/q(\boldsymbol{\Theta})\} q(\boldsymbol{\Theta}) d\boldsymbol{\Theta}$  and  $KL = \int \log\{q(\boldsymbol{\Theta})/P(\boldsymbol{\Theta} | \mathbf{Y})\} q(\boldsymbol{\Theta}) d\boldsymbol{\Theta}$  is the Kullback-Leibler divergence from  $q(\boldsymbol{\Theta})$  to  $P(\boldsymbol{\Theta} | \mathbf{Y})$  which is nonnegative, so that  $F \leq \log P(\mathbf{Y})$  with equality iff  $q(\boldsymbol{\Theta}) = P(\boldsymbol{\Theta} | \mathbf{Y})$ . Viewing  $q(\boldsymbol{\Theta})$  as an approximation to  $P(\boldsymbol{\Theta} | \mathbf{Y})$ ,  $KL$  quantifies the degree of separation between the posterior and its approximation. We restrict  $q(\boldsymbol{\Theta})$  to a manageable class of density functions, and minimize  $KL$  within this class, which is equivalent to maximizing the functional  $F$ . To make this tractable, the parameter vector is separated into low-dimensional components  $\boldsymbol{\Theta} = (\boldsymbol{\Theta}_1, \dots, \boldsymbol{\Theta}_k)$

and the approximation is assumed to factorize as  $q(\boldsymbol{\Theta}) = \prod_{l=1}^k q_l(\boldsymbol{\Theta}_l)$ . We use the calculus of variations to take functional derivatives of  $F$  with respect to each  $q_l(\boldsymbol{\Theta}_l)$ , while holding the others

fixed. This results in the update equations  $q_l(\boldsymbol{\Theta}_l) \propto \exp\{E_{\boldsymbol{\Theta}_{-l}}[\log P(\boldsymbol{\Theta}_l | \mathbf{Y}, \boldsymbol{\Theta}_{-l})]\}$ ,  $l = 1, \dots, k$  where  $P(\boldsymbol{\Theta}_l | \mathbf{Y}, \boldsymbol{\Theta}_{-l})$  is the density of the full conditional distribution of  $\boldsymbol{\Theta}_l$ , and the expectation is taken with respect to  $q_{-l}(\boldsymbol{\Theta}_{-l}) = \prod_{i \neq l} q_i(\boldsymbol{\Theta}_i)$ , so that the update equations are coupled and therefore iterated until convergence. For a typical dataset, the algorithm will converge to a solution in roughly 15 minutes to 2 hours on a fast laptop; whereas, an MCMC-based approach would take several weeks of computing time on a standard high-performance computing cluster. In [3] we compare our methodology to several competing approaches, including Tikhonov regularization and L1-regularization. Our studies reveal practical advantages to our approach, both in terms of the properties of estimators examined through simulation experiments, as well as in the prediction of real MEG and EEG data.

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# The $C^*$ -envelope of an operator algebra

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Bela Sz. Nagy developed a dilation theory for a single operator in the 1950s. It was built into a major tool in operator theory in joint work with Foiaş [11]. In 1967, Arveson [1] wrote a seminal paper extending dilation theory to arbitrary operator algebras. Two notions, boundary representations and the  $C^*$ -envelope, play a central role in his theory. It has been incredibly influential in operator theory and operator algebras in many ways. Only recently has the final piece been obtained to validate this theory in complete generality.

An *operator algebra* is a norm-closed subalgebra of  $\mathcal{B}(H)$ , the algebra of all bounded linear operators on a Hilbert space  $H$ . In addition to the natural Banach algebra structure that  $A$  inherits, it comes with a family of norms on  $\mathcal{M}_n(A)$ , the ring of  $n \times n$  matrices with coefficients in  $A$ , obtained by considering  $\mathcal{M}_n(A)$  as a subalgebra of  $\mathcal{M}_n(\mathcal{B}(H))$ , which is naturally identified with  $\mathcal{B}(H^{(n)})$ , where  $H^{(n)} = H \oplus \cdots \oplus H$  is the direct sum of  $n$  copies of  $H$ . For convenience, we assume that  $A$  is unital.

A map  $\phi: A \rightarrow \mathcal{B}(K)$  determines maps  $\phi^{(n)}: \mathcal{M}_n(A) \rightarrow \mathcal{B}(K^{(n)})$  by applying  $\phi$  to each coordinate. If  $\phi$  is a homomorphism, then so is each  $\phi^{(n)}$ . Say that  $\phi$  is *completely contractive* if  $\sup_{n \geq 1} \|\phi^{(n)}\| \leq 1$ . A *representation* of a unital operator algebra  $A$  is a unital completely contractive homomorphism into some  $\mathcal{B}(K)$ . This map is called *completely isometric* if each  $\phi^{(n)}$  is isometric for  $n \geq 1$ . If  $B$  is a  $C^*$ -algebra, the completely contractive representations coincide with the  $*$ -representations; and every faithful (injective) representation is completely isometric.

There is an abstract characterization of unital operator algebras [3] which is analogous to the classical definition of an abstract  $C^*$ -algebra. We won't discuss that here. However we do want to observe that if  $A$  is a closed subalgebra of a  $C^*$ -algebra  $B$ , then  $C^*$ -algebra theory provides a faithful representation of  $B$ ; and this restricts to a completely isometric representation of  $A$ . Different completely isometric representations of  $A$  generate different (non-isomorphic)  $C^*$ -algebras. We want to define a preferred choice for the  $C^*$ -algebra generated by such a copy of  $A$ .

An *operator system*  $S$  is a unital self-adjoint closed subspace of a  $C^*$ -algebra  $B$ . As  $S$  contains a spanning set of positive elements, we can say that a map  $\phi: S \rightarrow \mathcal{B}(H)$  is positive if  $0 \leq \phi(s)$  whenever  $0 \leq s \in S$ . We say that  $\phi$  is *completely positive* if  $\phi^{(n)}$  is positive for all  $n \geq 1$ . See [10] for a nice treatment of all of these ideas.

The classical situation is a *function algebra*  $A$ , which is a unital closed subalgebra of  $C(X)$  for some compact Hausdorff space  $X$ . There is a unique smallest closed subset  $\partial A$  of  $X$ , known as the

*Shilov boundary*, such that every  $f \in A$  attains its norm on  $\partial A$ . So the restriction to  $\partial A$  is a  $*$ -homomorphism of  $C(X)$  onto  $C(\partial A)$  which is isometric on  $A$ . The standard example is the disc algebra,  $A(\mathbb{D})$ , of all continuous functions on the closed unit disc  $\mathbb{D}$  that are analytic on the open disc. The maximum modulus principle shows that the Shilov boundary is the unit circle.

A more refined result identifies the *Choquet boundary* as those points  $x \in X$  such that the point evaluation map  $\delta_x(f) = f(x)$  on  $A$  has a unique Hahn-Banach extension to  $C(X)$ . This is usually described by saying that there is a unique measure  $\mu$  on  $X$ , namely the point mass at  $x$ , such that  $f(x) = \int f d\mu$  for all  $f \in A$ . The Choquet boundary is always a dense  $G_\delta$  subset of the Shilov boundary. See [8] for more on function algebras.

Arveson [1] defined the  *$C^*$ -envelope* of an operator algebra  $A$  to be a  $C^*$ -algebra  $B := C_{\text{env}}^*(A)$  together with a completely isometric isomorphism  $\iota$  of  $A$  into  $B = C^*(\iota(A))$  with the co-universal property that whenever  $j: A \rightarrow C$  is a completely isometric representation of  $A$  into a  $C^*$ -algebra  $C = C^*(j(A))$ , then there is a  $*$ -homomorphism  $\rho$  of  $C$  onto  $B$  such that  $\iota = \rho j$ . In the function algebra case, this reduces to  $C_{\text{env}}^*(A) = C(\partial A)$ . The  $C^*$ -envelope makes it possible to understand the representation theory of an arbitrary operator algebra in terms of the representation theory of this associated  $C^*$ -algebra.

Arveson also defines an analogue of the Choquet boundary. He shows that every completely contractive representation of  $A$  into  $\mathcal{B}(H)$  extends to a completely positive map of the operator system  $S = A + A^*$ . He establishes a Hahn-Banach type result showing that this further extends to a completely positive map of the  $C^*$ -algebra  $B$  into  $\mathcal{B}(H)$ . This can be interpreted as saying that  $\mathcal{B}(H)$  is an injective object in the category of operator systems with completely positive maps as morphisms. A representation of  $A$  has the *unique extension property* if the completely positive extension to  $B$  is unique and it is a  $*$ -representation. In particular, an irreducible  $*$ -representation  $\pi$  of  $B$  is a *boundary representation* if  $\pi|_A$  has the unique extension property. Arveson conjectured that every operator algebra should have sufficiently many boundary representations so that their direct sum yields a completely isometric representation  $\pi$ . When this holds,  $C_{\text{env}}^*(A) \simeq C^*(\pi(A))$ .

Hamana [9] showed that every operator system imbeds into a unique minimal injective operator system, the *injective envelope*. A result of Choi and Effros [4] endows every injective operator system with a natural  $C^*$ -algebra structure. Hamana showed that the  $C^*$ -subalgebra of the injective envelope generated by  $A$  is the  $C^*$ -envelope, thereby establishing its existence in complete generality.

A new proof due to Dritschel and McCullough [6] took a different approach. A *dilation* of a representation  $\pi$  of  $A$  on  $H$  is a representation  $\sigma$  on a Hilbert space  $K \supset H$  such that  $P_H \sigma(a)|_H = \pi(a)$  for  $a \in A$ . The space  $K$  decomposes as  $K = K_- \oplus H \oplus K_+$  so that  $\sigma(a)$  has the form  $\begin{bmatrix} * & 0 & 0 \\ * & \pi(a) & 0 \\ * & * & * \end{bmatrix}$ . A representation  $\pi$  is *maximal* if every dilation  $\sigma$  of  $\pi$  has the form

$\sigma \simeq \pi \oplus \sigma'$ . Dritschel and McCullough show that every representation dilates to a maximal representation; and that maximal representations have the unique extension property. Thus if  $\pi$  is a maximal dilation of a completely isometric one, then  $C_{\text{env}}^*(A) \simeq C^*(\pi(A))$ .

This still doesn't yield boundary representations. Arveson [2] revisited the situation. Using disintegration of measure techniques, he shows that when  $A$  is separable, a maximal completely isometric representation of  $A$  decomposes as a direct integral of boundary representations (almost everywhere). Thus sufficiently many boundary representations exist.

Last year, Matthew Kennedy and I [5] found a much simpler and more general dilation theory argument in the spirit of Arveson's original paper. A completely positive map  $\phi$  of  $S$  into  $\mathcal{B}(H)$  is *pure* if  $\mathbb{R}_+\phi$  is an extreme ray in the positive cone of all completely positive maps of  $S$  into  $\mathcal{B}(H)$ . Beginning with a pure unital completely positive map on  $S$ , we dilate it one dimension at a time, to eventually obtain a pure maximal unital completely positive map. This will have the unique extension property, and the extension to  $B$  will be irreducible; whence it is a boundary representation. When we begin with a pure representation of  $A$ , extend it to  $S$ , and apply this procedure, the intermediate dilations will not be multiplicative. However this is recovered at the final stage.

One also needs to show that there are sufficiently many pure maps on  $S$ . This follows from some convexity results of Farenick [7] on completely positive maps into matrix algebras. A nice idea of Craig Kleski allows us to produce a simpler proof directly from our dilation result of the previous paragraph. Thus the  $C^*$ -envelope is obtained as a direct sum of boundary representations.

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## SUBVENTIONS POUR CAMPS MATHÉMATIQUES 2014

La SMC accepte en ce moment les demandes de subvention pour l'organisation de quelques nouveaux camps mathématiques en 2014.

Les subventions pour camps mathématiques procurent une partie du financement nécessaire à une personne qui souhaite organiser un camp mathématique dans son université ou son cégep. Il peut s'agir d'un camp avec hébergement ou d'un camp de jour, qui cible habituellement les étudiants et les enseignants de la région desservie par l'établissement d'enseignement. La SMC souhaite particulièrement étendre ses camps spécialisés aux groupes sous-représentés et aux enseignants. Pour tous les détails sur les camps mathématiques, consultez le <http://cms.math.ca/Camps/>.

Veuillez nous faire parvenir par courriel votre demande de subvention, qui comprendra une description du projet de camp et un budget, au plus tard le 1<sup>er</sup> mai 2014 à l'adresse [camps-coordinator@smc.math.ca](mailto:camps-coordinator@smc.math.ca).



**Canadian Mathematics Education Forum (CMEF)**  
University of Ottawa • May 1-4 • Ottawa, Ontario

## Adrien Pouliot Award

Nominations of individuals or teams of individuals who have made significant and sustained contributions to mathematics education in Canada are solicited. Such contributions are to be interpreted in the broadest possible sense and might include: community outreach programs, the development of a new program in either an academic or industrial setting, publicizing mathematics so as to make mathematics accessible to the general public, developing mathematics displays, establishing and supporting mathematics conferences and competitions for students, etc.

Nominations must be received by the CMS Office no later than **April 30, 2014**.

Please submit your nomination electronically, preferably in PDF format, to [apaward@cms.math.ca](mailto:apaward@cms.math.ca).

### Nomination requirements:

- Include contact information for both nominee and nominator.
- Describe the nominated individual's or team's sustained contributions to mathematics education. This description should provide some indication of the time period over which these activities have been undertaken and some evidence of the success of these contributions. This information must not exceed four pages.
- Two letters of support from individuals other than the nominator should be included with the nomination.
- Curricula vitae should not be submitted since the information from them relevant to contributions to mathematics education should be included in the nomination form and the other documents mentioned above.
- If nomination was made in the previous year, please indicate this.
- Members of the CMS Education Committee will not be considered for the award during their tenure on the committee.

### Renewals

Individuals who made a nomination last year can renew this nomination by simply indicating their wish to do so by the deadline date. In this case, only updating materials need be provided as the original has been retained.

## Prix Adrien Pouliot

Nous sollicitons la candidature de personne ou de groupe de personnes ayant contribué d'une façon importante et soutenue à des activités mathématiques éducatives au Canada. Le terme « contributions » s'emploie ici au sens large; les candidats pourront être associés à une activité de sensibilisation, un nouveau programme adapté au milieu scolaire ou à l'industrie, des activités promotionnelles de vulgarisation des mathématiques, des initiatives, spéciales, des conférences ou des concours à l'intention des étudiants, etc.

Les mises en candidature doivent parvenir au bureau de la SMC avant le **30 avril 2014**.

Veuillez faire parvenir votre mise en candidature par voie électronique, de préférence en format PDF, à [prixap@smc.math.ca](mailto:prixap@smc.math.ca).

### Conditions de candidature

- Inclure les coordonnées du/des candidats ainsi que le(s) présentateur(s).
- Décrire en quoi la personne ou le groupe mise en candidature a contribué de façon soutenue à des activités mathématiques. Donner un aperçu de la période couverte par les activités visées et du succès obtenu. La description ne doit pas être supérieure à quatre pages.
- Le dossier de candidature comportera deux lettres d'appui signées par des personnes autres que le présentateur.
- Il est inutile d'inclure des curriculum vitae, car les renseignements qui s'y trouvent et qui se rapportent aux activités éducatives visées devraient figurer sur le formulaire de mise en candidature et dans les autres documents énumérés ci-dessus.
- Si la mise en candidature a été soumise en l'année précédente, s'il vous plaît indiquez-le.
- Les membres du Comité d'éducation de la SMC ne pourront être mise en candidature pour l'obtention d'un prix pendant la durée de leur mandat au Comité.

### Renouveler une mise en candidature

Il est possible de renouveler une mise en candidature présentée l'an dernier, pourvu que l'on en manifeste le désir avant la date limite. Dans ce cas, le présentateur n'a qu'à soumettre des documents de mise à jour puisque le dossier original a été conservé.



Use Social Media? So do we!  
Aimez la SMC sur Facebook



Use Social Media? So do we!!  
Suivez la SMC sur Twitter







## 2014 CMS Summer Meeting Winnipeg - June 6-9



June 6 - 9, 2014

Delta Winnipeg, Winnipeg (Manitoba)

Host: University of Manitoba

[cms.math.ca](http://cms.math.ca)

### Prizes | Prix

Coxeter-James Prize | Prix Coxeter-James

to be announced | à être annoncé

David Borwein Distinguished Career Award

Prix David-Borwein de mathématicien émérite pour  
l'ensemble d'une carrière

to be announced | à être annoncé

Excellence in Teaching Award

Prix d'excellence en enseignement

Gerda De Vries (Alberta)

Krieger-Nelson Prize Lecture

Conférence - Prix Krieger-Nelson

to be announced | à être annoncé

6-9 juin 2014

Delta Winnipeg, Winnipeg (Manitoba)

Hôte : Université du Manitoba

[cms.smc.ca](http://cms.smc.ca)

### Public Lectures | Conférences publiques

Barbara Keyfitz (Ohio State)

### Plenary Speakers | Conférences plénières

Bela Bollobas (Cambridge, Memphis)

Mark Lewis (Alberta)

James Maynard (Montreal)

John Mighton (Fields)

Thomas Ransford (Laval)

### Scientific Director | Directeur scientifique

Nina Zorboska (University of Manitoba)

Stephen Kirkland (University of Manitoba)

### Related Events | Événements liés

The CMS Executive is inviting all CMS members and meeting participants to join them at an informal luncheon at the CMS Annual General Meeting to focus on what was achieved in 2013. There will be a short presentation followed by questions and answers. This is an opportunity for participants to get together with the CMS Executive and discuss emerging issues as well as directly voice their opinions, concerns and interests.

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

Winnipeg will feature an art exhibit including art projects from Students in the Math in Art course from the University of Winnipeg by teacher Derek Brueckner.

Registration is  
now open! / les  
inscriptions sont  
ouvertes



Réunion d'été 2014  
de la SMC  
Winnipeg - 6-9 juin



## Confirmed Regular Sessions | Sessions générales

### Analytic methods in Diophantine equations Méthodes analytiques pour les équations Diophantiennes

Michael Coons (University of Newcastle),  
Patrick Ingram (Colorado State)

### Complex Analysis and Function Spaces Analyse complexe et espaces de fonctions

Eric Schippers, Nina Zorboska (Manitoba)

### Gröbner bases and Computer Algebra Bases de Gröbner et Algèbre Informatique

Murray Bremner, Sara Madariaga (Saskatchewan), Yang Zhang,  
Jaydeep Chipalkatti, R. Padmanabhan (Manitoba)

### Innovation and outreach in mathematics education Innovation et promotion en enseignement des mathématiques

Darja Kalajdziewska (Manitoba), Anna Stokke (Winnipeg)

### Low dimensional topology and geometric group theory | Topologie en basse dimension et théorie géométrique des groupes

Adam Clay (Manitoba), Eduardo Martinez-Pedroza (Memorial)  
Dale Rolfsen (UBC)

### Mathematical Biology | Biologie mathématique

Abba Gumel (Manitoba)

### Graphs and Hypergraphs | Graphes et Hypergraphes

David Gunderson, Bill Kocay (Manitoba), Ortrud Oellermann (Winnipeg)

### Algebraic Tools and Design Theory | Outils algébriques et design combinatoire

Robert Craigen (Manitoba)

### Mathematics: Tools of investigation in cellular and molecular biology | Mathématiques: Outils pour l'étude de la biologie cellulaire et moléculaire

Eric Cytrynbaum (UBC), Stephanie Portet (Manitoba)

### Numerical Analysis and Scientific Computing Analyse numérique et Calcul scientifique

A.Bass Bagayogo (Université de Saint-Boniface)

### Preserver problems | Problèmes de préservation

CK Li (College of William an Mary), SH Lui (Manitoba),  
YT Poon (Iowa State)

### Symplectic geometry and equivariant topology Géométrie symplectique et topologie équivariante

Thomas Baird (Memorial), Derek Krepski (Manitoba)

### Topics in Approximation Theory Sujets variés en théorie de l'approximation

Kirill Kopotun (Manitoba), Andriy Prymak (Manitoba)

### Contributed Papers | Communications libres

A.Bass Bagayogo (Université de Saint-Boniface)

### AARMS-CMS Student Poster Session Présentations par affiches pour étudiants

Svenja Huntemann (Dalhousie)



Early bird  
deadline is April 11!  
Inscription lève tôt  
le 11 avril !



*continued from page 5*

**JUNE 2014**

**4-9 Dynamics in Geometric Dispersive Equations and the Effects of Trapping, Scattering and Weak Turbulence**  
<http://www.birs.ca/events/2014/5-day-workshops/14w5080>

**4-11 Alexandrov Geometry** <http://www.birs.ca/events/2014/research-in-teams/14rit188>

**5-9 Kakeya Problem, etc** (*Los Angeles, CA*)  
<http://www.ipam.ucla.edu/programs/ccgws2/>

**5-9 Projective modules and A1-homotopy theory** (*Palo Alto, CA*)  
<http://www.aimath.org/ARCC/workshops/projectiveA1.html>

**6-7 Atlantic General Relativity 2014 Organizers: Sanjeev Seahra, Jack Gegenberg** (*University of New Brunswick (Fredericton)*)

**10-11 12<sup>th</sup> Western Canadian Linear Algebra Meeting**  
(University of Regina, SK) <http://uregina.ca/~abstsubm/index.html>

**11-16 Mathematical Finance: Arbitrage and Portfolio Optimization** <http://www.birs.ca/events/2014/5-day-workshops/14w5116>

**12-23 Random Matrix theory** (*Princeton University, NJ*)  
[www.math.ias.edu/wam/2014](http://www.math.ias.edu/wam/2014)

**16-17 22<sup>nd</sup> Ontario Combinatorics Workshop** (*York Univ. ON*) [www.fields.utoronto.ca/programs/scientific/13-14/OCW14/](http://www.fields.utoronto.ca/programs/scientific/13-14/OCW14/)

**18-23 Imaging and Modeling in Electron Microscopy - Recent Advances** <http://www.birs.ca/events/2014/5-day-workshops/14w5048>

**19 Bers 100 celebration** (CUNY, NY)  
<http://fsw01.bcc.cuny.edu/zhe.wang/IB.html>

**20–25 16<sup>th</sup> International Conference on Fibonacci Numbers**  
(Rochester, NY) <http://www.mathstat.dal.ca/Fibonacci/>

**25-30 Geometric Aspects of Semilinear Elliptic and Parabolic Equations: Recent Advances and Future Perspectives** <http://www.birs.ca/events/2014/5-day-workshops/14w5017>

**26 Niven Lecture - Bjorn Poonen** (*University of British Columbia*)  
<http://www.pims.math.ca/scientific-event/140526-nlbp>

**26–30 European Conference on Elliptic & Parabolic Problems** (*Gaeta, Italy*) <http://www.math.uzh.ch/index.php/conferencedetails>

**29 PIMS Public Seminar: Jim Gates** (*University of British Columbia*)  
<http://www.pims.math.ca/scientific-event/140529-ppsja>

**June 1-6 The Future of Trace Formulas** <http://www.birs.ca/events/2014/5-day-workshops/14w5001>

**2-27 2014 Summer School in Probability** (University of British Columbia) <http://www.pims.math.ca/scientific-event/140602-ssp>

**6-9 CMS Summer Meeting** (Winnipeg) [cms.math.ca/events/summer14](http://cms.math.ca/events/summer14)

**8-13 Integrability in Holography (HALF)** <http://www.birs.ca/events/2014/5-day-workshops/14w5070>

**8-13 Programming with Chemical Reaction Networks: Mathematical Foundations (HALF)** <http://www.birs.ca/events/2014/5-day-workshops/14w5167>

**9-14 String Math Conference - 2014** (*University of Alberta*) <http://www.pims.math.ca/scientific-event/140609-smc>

**15–20 Quantum curves and Quantum Knot invariants** (*Banff, AB*) <http://www.birs.ca/events/2014/5-day-workshops/14w5073>

**15-22 Dirichlet spaces and de Branges-Rovnyak spaces**  
<http://www.birs.ca/events/2014/research-in-teams/14rit183>

**20-21 Conference on Graph Theory, Matrix Theory and Interactions** (*Queen's University*)

**22-27 Emerging Statistical Challenges and Methods For Analysis of Massive Genomic Data in Complex Human Disease Studies** <http://www.birs.ca/events/2014/5-day-workshops/14w5011>

**22-July 5 2014 Summer IMO Training Camp** <http://www.birs.ca/events/2014/summer-schools/14ss172>

**29-July 4 Entropy Methods, PDEs, Functional Inequalities, and Applications** <http://www.birs.ca/events/2014/5-day-workshops/14w5109>

## JULY 2014

**July 6-11 New Directions in Financial Mathematics and Mathematical Economics** <http://www.birs.ca/events/2014/5-day-workshops/14w5168>

**13-18 Stochastic Network Models of Neocortex (a Festschrift for Jack Cowan)** <http://www.birs.ca/events/2014/5-day-workshops/14w5138>

**20-25 Spin Glasses and Related Topics** <http://www.birs.ca/events/2014/5-day-workshops/14w5082>

**20-27 Spectrum Asymptotics of Operator Pencils** <http://www.birs.ca/events/2014/research-in-teams/14rit182>





<http://cms.math.ca/Scholarships/Moscow>

<http://cms.math.ca/Bourses/Moscou>

## CMS - NSERC Math in Moscow

The Canadian Mathematical Society (CMS) and the Natural Sciences and Engineering Research Council (NSERC) provide \$9,000 scholarships to Canadian students registered in a mathematics or computer science program.

The scholarships are to attend a semester at the small, elite Moscow Independent University.

**Deadline:**  
**March 30, 2014** to attend the Fall 2014 semester

**September 30, 2014** to attend the Winter 2015 semester.

## SMC - CRSNG Math à Moscou

La Société mathématique du Canada (SMC) et le Conseil de Recherches en Sciences Naturelles et en Génie du Canada (CRSNG) offrent des bourses de 9,000 \$ chacune. Les étudiantes ou étudiants du Canada inscrit(e)s à un programme de mathématiques ou d'informatique sont éligibles.

Les bourses servent à financer un trimestre d'études à la petite université d'élite Moscow Independent University.

**Date limite:**  
**30 mars 2014** pour le trimestre de l'automne 2014.

**30 septembre 2014** pour le trimestre d'hiver 2015.



[www.mccme.ru/mathinmoscow](http://www.mccme.ru/mathinmoscow)





## CANADIAN MATHEMATICAL BULLETIN (CMB)

### EDITOR-IN-CHIEF (EIC) AND OTHER EDITORS

The CMS invites expressions of interest for the Editor-In-Chief (EIC) of CMB; two EICs are being solicited, with a term scheduled to commence in June 2014. Funding support from the CMS is available for both these EIC positions.

In addition, the CMS intends to expand the current compliment of supporting editors for the CMS journals and is also soliciting interest in the following editorships:

#### Assistant Editor-in-Chief Technical Editor

#### Graphics Editor Managing Editor

Expressions of interest should include a covering letter indicating the type of editorships you are interested in or becoming involved with, your curriculum vitae, and an expression of views regarding the publication. For EIC consideration, please also include an indication of support from your respective university.

Please submit your expression of interest electronically to: [CMB-EIC-2014@cms.math.ca](mailto:CMB-EIC-2014@cms.math.ca) before April 15, 2014.

#### Current CJM/CMB Editorial Board:

Terry Gannon (Alberta)	Editor-in-Chief CMB
Henry Kim (Toronto)	Editor-in-Chief CJM
Robert McCann (Toronto)	Editor-in-Chief CJM
Volker Runde (Alberta)	Editor-in-Chief CMB
Louigi Addario-Berry	Associate Editor
Florin Diacu (Victoria)	Associate Editor
Ilijas Farah (York)	Associate Editor
Skip Garibaldi (Emory University)	Associate Editor
Dragos Ghioca (UBC Vancouver)	Associate Editor
Eyal Goren (McGill)	Associate Editor
Robert Leon Jerrard (Toronto)	Associate Editor
Izabella Laba (UBC Vancouver)	Associate Editor
Assaf Naor (Courant)	Associate Editor
Anthony To-Ming Lau (Alberta)	Associate Editor
Alexander Litvak (Alberta)	Associate Editor
Alexander Nabutovsky (Toronto)	Associate Editor
Erhard Neher (Ottawa)	Associate Editor
Frank Sottile (Texas A&M)	Associate Editor
McKenzie Wang (McMaster)	Associate Editor
Michael Ward (UBC Vancouver)	Associate Editor
Juncheng Wei (UBC Vancouver)	Associate Editor
Dani Wise (McGill)	Associate Editor
Jie Xiao (Memorial)	Associate Editor
Efim Zelmanov (UCSD)	Associate Editor



## BULLETIN CANADIEN DE MATHÉMATIQUES (BCM)

### RÉDACTEUR EN CHEF ET AUTRES POSTES

La SMC invite les personnes intéressées par un poste de rédacteur en chef au BCM à lui faire part de leur intérêt. Deux postes de rédacteurs en chef sont à pourvoir, pour un mandat qui commencera en juin 2014. La SMC offre du soutien financier pour ces deux postes.

La SMC souhaite en outre élargir le bassin de rédacteurs qui appuient les activités de rédaction de ses revues. Elle sollicite donc également des candidatures aux postes suivants :

#### rédacteur en chef adjoint rédacteur technique

#### infographiste rédacteur gérant

Les propositions de candidature comprendront les éléments suivants : une lettre de présentation précisant le type de poste qui vous intéresse, votre curriculum vitae et un texte dans lequel vous exprimez votre opinion et vos idées par rapport à la publication. Pour les postes de rédacteur en chef, veuillez ajouter une preuve du soutien de votre université.

Veuillez faire parvenir votre candidature par courriel à : [CMB-EIC-2014@cms.math.ca](mailto:CMB-EIC-2014@cms.math.ca) au plus tard le 15 avril 2014.

#### Conseil de rédaction pour le CJM et le BCM à présent:

Terry Gannon (Alberta)	Rédacteur en chef du BCM
Henry Kim (Toronto)	Rédacteur en chef du CJM
Robert McCann (Toronto)	Rédacteur en chef du CJM
Volker Runde (Alberta)	Rédacteur en chef du BCM
Louigi Addario-Berry (McGill)	Rédacteur associé
Florin Diacu (Victoria)	Rédacteur associé
Ilijas Farah (York)	Rédacteur associé
Skip Garibaldi (Emory University)	Rédacteur associé
Dragos Ghioca (UBC Vancouver)	Rédacteur associé
Eyal Goren (McGill)	Rédacteur associé
Robert Leon Jerrard (Toronto)	Rédacteur associé
Izabella Laba (UBC Vancouver)	Rédactrice associée
Assaf Naor (Courant)	Rédacteur associé
Anthony To Ming Lau (Alberta)	Rédacteur associé
Alexander Litvak (Alberta)	Rédacteur associé
Alexander Nabutovsky (Toronto)	Rédacteur associé
Erhard Neher (Ottawa)	Rédacteur associé
Frank Sottile (Texas A&M)	Rédacteur associé
McKenzie Wang (McMaster)	Rédacteur associé
Michael Ward (UBC Vancouver)	Rédacteur associé
Juncheng Wei (UBC Vancouver)	Rédacteur associé
Dani Wise (McGill)	Rédacteur associé
Jie Xiao (Memorial)	Rédacteur associé
Efim Zelmanov (UCSD)	Rédacteur associé



## 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: researchers having their PhD degrees conferred in 2004 or later will be eligible for nomination in 2014 for the 2015 prize. 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. The prize lecture will be given at the 2014 CMS Winter Meeting.

**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. The prize lecture will be given at the 2015 CMS Summer Meeting.

**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. The prize lecture will be given at the 2015 CMS Summer Meeting.

The deadline for nominations is **June 30, 2014**.

Nominators should ask at least three referees to submit letters directly to the CMS by September 30, 2014. Some arms-length referees are strongly encouraged. Nomination letters should list the chosen referees, and should include a recent curriculum vitae for the nominee, if available. Nominations and reference letters should be submitted electronically, preferably in PDF format, by the appropriate deadline to the corresponding email address:

Coxeter-James: [cjprize@cms.math.ca](mailto:cjprize@cms.math.ca)

Jeffery-Williams: [jwprize@cms.math.ca](mailto:jwprize@cms.math.ca)

Krieger-Nelson: [knprize@cms.math.ca](mailto:knprize@cms.math.ca)

## Prix de recherche

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 : ceux qui ont obtenu leur doctorat en 2004 ou après seront admissibles en 2014 pour le prix 2015. 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<sup>e</sup> année suivant l'obtention du doctorat. La personne choisie prononcera sa conférence à la Réunion d'été SMC 2015.

**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. La personne choisie prononcera sa conférence à la Réunion d'hiver SMC 2014.

**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. La lauréate prononcera sa conférence à la Réunion d'été SMC 2015.

La date limite de mises en candidature est le **30 juin 2014**.

Les proposants doivent faire parvenir trois lettres de référence à la SMC au plus tard le 30 septembre 2014. Nous vous incitons fortement à fournir des références indépendantes. 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, avant la date limite, à l'adresse électronique correspondante:

Coxeter-James: [prixcj@smc.math.ca](mailto:prixcj@smc.math.ca)

Jeffery-Williams: [prixjw@smc.math.ca](mailto:prixjw@smc.math.ca)

Krieger-Nelson: [prixkn@smc.math.ca](mailto:prixkn@smc.math.ca)

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

**CMS Notes / Notes de la SMC**

209 - 1725 St. Laurent Blvd Ottawa, ON K1G 3V4 Canada