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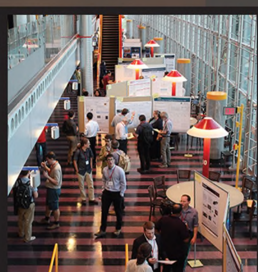

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"Glass Fireworks" by Amit Rambaran, Emery Collegiate Institute, North York, ON – Honourable Mention (High School Individual Category), 2014 Art of Physics competition. See http://www.cap.ca/aop/art.html.

The Local Organizing Committee (2nd and 3rd from left) deliver a memorable experience for all Congress delegates attending the 2016 CAP Congress in Ottawa, ON.

<< Glass Fireworks >> par Amit Rambaran, Emery Collegiate Institute, North York, ON – mention honorable (catégorie élèves), Concours l'Art de la physique 2014. Voir http://www.cap.ca/aop/art.html .

Le Comité organisateur local (2e et 3e de gauche) a fait du Congrès 2016 à Ottawa, Ontario, une expérience mémorable pour tous les délégués.

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Les tarifs et dimensions des publicités (en vigueur depuis janvier 2016) ainsi que les formulaires d'abonnement et de commande de numéros individuels se trouvent sur le site internet de l'ACP (www.cap.ca -> Publications -> La Physique au Canada).

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OPEN ACCESS AND THE FUTURE OF ACADEMIC PUBLISHING

Academic publishing is undergoing major changes, not only because of the shift from print to electronic, but also as a result of profound cultural changes brought about by technology. It is forcing both non-profit and profit-driven scientific publishers to adapt.

The advent of the internet and the general availability of portable devices are facilitating the diffusion of information. In academic circles and the general public, there is an increased demand for open access to information, and this includes access to published scientific research (see for instance the website for the lobby group Right to Research Coalition [1]). There is a thirst for information. Among the young in particular, there is a reluctance to pay for any electronic material. All means possible are developed to access information free of charge and this is also occurring in academic circles. This cultural shift is clashing with corporate interests and also affecting non-profit scientific organizations relying on publishing revenues to fund their programs.

The growing expectation of having access to scientific material freely has led journals to offer "open access" options to authors at a fee. It has also led to the creation of open access journals where the authors pay fees for publication. Canada has now its own, FACETS, launched last April, our first and only multidisciplinary open access journal [2,3].

The Government of Canada's requirement that all journal articles resulting from research receiving federal funding should be open access is simply a response to this growing pressure. The same applies to the work of government scientists in the USA. In Canada, realizing that it is not practical to require all published work to be in open access journals that require hefty fees, "green" solutions are permitted where some version of the paper is deposited in a freely accessible repository such as arxiv.org. The pressure is nevertheless on authors to publish some of their papers in open access journals for immediate visibility.

The open access option will not satisfy the need for easy access to information since this is transferring the cost of publishing to researchers already facing tight budgets, and the public still faces restricted access to most published material. Compounding the problem is the large number of academics outside the developed world who cannot afford the fees to legitimately download journal articles, typically about US$30 per article. They are forced to use servers bypassing the copyright charges. Sci-Hub, one such site, was created by a frustrated graduate student from Kazakhstan, Alexandra Elbakyan [4]. It hosts PDFs of papers offered by academics around the world. Over a six month period ending in March 2016 it served up 28 million documents. Analysing the data, John Bohannon found that Sci-Hub was accessed from all corners of the globe including places where legitimate access was available, such as the US and Canada [4]. A recent survey made by the journal *Science* illustrates the extent of a cultural shift to a situation where access to information is considered a right [5]. The survey showed that most respondents, nearly 90%, did not think that it was wrong to download pirated papers. Nearly 60% have used the illegal sites, of those 30% daily or weekly, and 37% used it despite having access to the articles through their institutions. They were doing it either for convenience or because they object to the profits publishers make off academics. The profits publishers make are an issue (Elsevier's 2014 profit was US$1.4 Billion), but the illegal downloads are also affecting the non-profit academic publishers who rely on publishing revenues to support and lobby for the scientific community [6].

The Publishing industry is fighting back using powerful legal means. Elbakyan, the founder of Sci-Hub, faces an uncertain future. Aaron Swartz, from the US, was arrested in 2011 for mass-downloading academic papers. Facing devastating financial penalties, he hanged himself [4]. But as we know, this is unlikely to shut down Sci-Hub or stop the drive for free information. It is all part of a larger phenomenon of freeing information and copyrighted material.

Béla Joós is a Professor of Physics at the University of Ottawa. He has been a member of the Editorial Board of Physics in Canada since January 1985 and took over as Editor in June 2006.

Béla Joós est professeur de physique à l'Université d'Ottawa. Il est membre du Comité de rédaction de la Physique au Canada depuis janvier 1985 et est devenu rédacteur en chef en juin 2006.

The contents of this journal, including the views expressed above, do not necessarily represent the views or policies of the Canadian Association of Physicists.

Le contenu de cette revue, ainsi que les opinions exprimées ci-dessus, ne représentent pas nécessairement les opinions ou les politiques de l'Association canadienne des physiciens et physiciennes.

The future of scholarly publishing is evolving fast and it is hard to predict how all this will unfold. The hunger for information is so strong and people are so resourceful that a reasonable equilibrium has to be found. In the movie and the music industries a new equilibrium of sorts exists but content is still being pirated. Concerning access to scholarly journals, it is more than likely that one size will not fit all. Academics in Canada and the US, for instance, will not live by the same rules as those in developing countries. And the situation will remain murky for a long time. The smart-phone generation, in the same way as they embraced Uber from its inception abandoning the use of taxis, are downloading from the most convenient sites unencumbered by legal issues. The various players will have to adjust. Nevertheless, the pressure is on to make journal downloads more affordable, so I am optimistic that we are heading towards a world with more easily accessible information on progress in research.

On a concluding note it is a mistake to believe that digital publishing is cheap. For magazines such as our own *Physics in Canada*, it may be nearly as expensive as print, with the high costs of developing and maintaining state of the art web sites and attractive formats, suitable for desktops, tablets and smart-phones. *Physics in Canada* is currently facing that challenge. There are costs associated with the delivery of information irrespective of format.

Béla Joós
University of Ottawa
Editor

Comments of readers on this Editorial are more than welcome.

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L'ACCÈS LIBRE ET L'AVENIR DES PUBLICATIONS SAVANTES

Les publications savantes subissent de profonds changements, non seulement à cause du passage de l'imprimé à la publication électronique, mais également en raison de changements culturels radicaux tenant à la technologie. Cela force les éditeurs scientifiques tant à but non lucratif que lucratif à s'adapter.

L'avènement d'Internet et la disponibilité générale des appareils portatifs facilitent la diffusion de l'information. Dans les milieux universitaires et le grand public, on exige de plus en plus le libre accès à l'information, y compris aux résultats publiés de recherches scientifiques (voir, par exemple, le site Web du groupe de pression Right to Research Coalition [1]). On a soif d'information. Chez les jeunes en particulier, on note une réticence à payer pour les documents électroniques. On prend tous les moyens possibles pour accéder à l'information sans frais, ce qu'on observe aussi dans les milieux universitaires. Ce changement culturel heurte les intérêts des entreprises et affecte aussi les organismes scientifiques à but non lucratif qui misent sur les revenus de l'édition pour financer leurs programmes.

Les attentes de plus en plus grandes à accéder librement aux documents scientifiques ont incité des revues à offrir aux auteurs la possibilité « d'accès libre », moyennant droits. Cela a aussi amené la création de revues à libre accès que les auteurs paient pour y publier. Le Canada a maintenant la sienne, FACETS, notre première et seule revue multidisciplinaire à libre accès, depuis avril dernier [2,3].

Si le gouvernement du Canada exige que tous les articles de revues découlant de recherches à financement fédéral soient libre d'accès, c'est simplement en réaction à ces pressions croissantes. Il en va de même pour les travaux des scientifiques gouvernementaux aux États-Unis. Au Canada, ayant constaté que la publication de tous les travaux dans des revues à libre accès moyennant des droits faramineux n'est pas pratique, les solutions « vertes » sont autorisées si une version du document est déposée dans un répertoire à accès libre, tel arXiv.org. Les auteurs sont cependant sous la pression de publier quelques-uns de leurs documents dans des revues à libre accès s'ils veulent une visibilité immédiate.

Le choix du libre accès ne répondra pas à la nécessité de faciliter l'accès à l'information puisqu'il reporte le coût de l'édition sur les chercheurs, déjà aux prises avec des budgets serrés, et que l'accès du public à la majeure partie des documents publiés demeure restreint. Ce qui complique le problème, c'est qu'un grand nombre d'universitaires hors du monde industrialisé ne peuvent télécharger des articles de revues de façon légitime, ce qui coûte généralement environ 30 $US par article. Ils sont forcés de passer par des serveurs qui contournent les droits d'auteur. L'un de ces serveurs, le Sci-Hub, a été créé par une étudiante diplômée frustrée du Kazakhstan, Alexandra Elbakyan [4]. On y retrouve en PDF des documents offerts par des universitaires du monde entier. En une période de six mois terminée en mars 2016, 28 millions de documents sont passés par ce serveur. L'analyse des données a permis à John Bohannon de constater qu'on accédait à Sci-Hub des quatre coins du monde, y compris des endroits où l'accès légitime est possible, comme les États-Unis et le Canada [4]. Un récent sondage de la revue *Science* montre l'ampleur d'un changement culturel à une situation où l'accès à l'information est considéré comme un droit [5]. D'après ce sondage, la majeure partie des répondants, près de 90%, ne croit pas que ce soit mal de télécharger des documents piratés. Près de 60% utilisent des sites illégaux, dont 30% chaque jour ou chaque semaine, et 37% en dépit du fait qu'ils ont accès aux articles par l'entremise de leurs établissements. Ils le font par commodité ou parce qu'ils s'opposent aux profits des éditeurs sur le dos des universitaires. Ces profits des éditeurs font problème (atteignant 1,4 milliard de dollars en 2014, dans le cas d'Elsevier), mais les téléchargements illégaux affectent aussi les éditeurs de publications savantes à but non lucratif qui misent sur les revenus de l'édition pour appuyer et promouvoir la collectivité scientifique [6].

L'industrie de l'édition réplique à l'aide de puissants moyens légaux. Elbakyan, fondatrice de Sci-Hub, fait face à un avenir incertain. Aaron Swartz, des États-Unis, a été arrêté en 2011 pour téléchargement massif de publications savantes. Devant des sanctions financières accablantes, il s'est pendu [4]. Mais, comme on le sait, il est peu probable que cela entraîne la fermeture de Sci-Hub ou freine la quête d'information gratuite. Tout cela s'inscrit dans le phénomène plus vaste de la libéralisation de l'information et de la protection des documents par le droit d'auteur.

L'avenir de l'édition savante évolue rapidement et il est difficile de prédire comment tout cela tournera. La soif d'information est si grande et les gens sont tellement inventifs qu'il faudra trouver un équilibre raisonnable. Dans les industries du film et de la musique, un nouvel équilibre s'est établi en quelque sorte, mais il y a toujours piratage de contenu. En ce qui a trait à l'accès aux revues savantes, une solution unique est plus qu'improbable. Les universitaires au Canada et aux États-Unis, par exemple, ne se plieront pas aux mêmes règles que ceux des pays en développement. Et la situation demeurera trouble pendant un bon moment. Tout comme elle a délaissé les taxis en faveur d'Uber dès sa création, la génération du téléphone intelligent télécharge à partir des sites les plus pratiques, sans se préoccuper de questions légales. Il appartiendra aux différents acteurs de s'adapter. Néanmoins, il y a une forte pression de rendre le téléchargement d'articles de revues plus accessible. Pour cette raison j'ai bon espoir que nous allons vers un monde bénéficiant d'informations plus facilement accessibles sur les progrès de la recherche.

En guise de conclusion, c'est une erreur de croire que l'édition numérique est peu coûteuse. Pour des revues comme la nôtre, *La Physique au Canada*, elle est aussi onéreuse que l'imprimé, compte tenu des coûts élevés qu'entraînent la conception et l'entretien de sites Web de pointe et de formats attrayants convenant aux ordinateurs de bureau, aux tablettes et aux téléphones intelligents. *La Physique au Canada* fait actuellement face à ce défi. Il y a des coûts associés à la livraison de l'information, quel que soit le format.

Béla Joós
Université d'Ottawa
Rédacteur en chef

Les commentaires des lecteurs sur cet éditorial sont toujours les bienvenus.

NOTE: Le genre masculin n'a été utilisé que pour alléger le texte.

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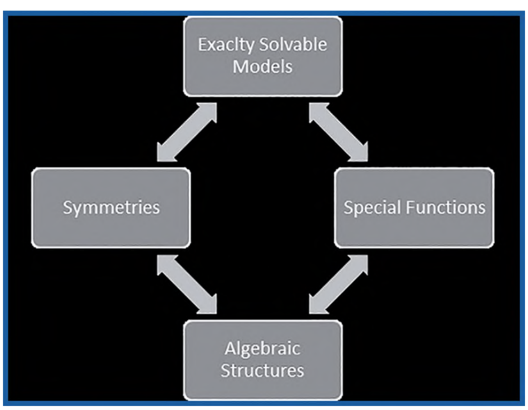
In 2016, the Division of Theoretical Physics (DTP), in partnership with the Winnipeg Institute for Theoretical Physics (WITP), created a PhD Thesis Prize competition for the best thesis in theoretical physics by any student receiving their PhD degree from a Canadian university in the current or prior calendar year (see http://www.cap.ca/en/div/dtp/thesis-prize). The DTP is pleased to announce that the recipient of the 2015-16 DTP-WITP Thesis Prize is Vincent X. Genest. Dr. Genest was awarded his PhD by the Université de Montréal in 2015 for the work "Algebraic Structures, Superintegrable Systems and Orthogonal Polynomials". A summary of Dr. Genest's thesis work appears below.

ALGEBRAIC STRUCTURES, SUPERINTEGRABLE SYSTEMS AND ORTHOGONAL POLYNOMIALS

BY VINCENT X. GENEST

The search for exactly solvable systems and their analysis has a long-standing tradition in mathematical physics. This is so because the study of exactly solvable models provides significant insight into fundamental principles, but also because these models form a bedrock for the study of symmetries. Indeed, exact solvability is often made possible by the presence of symmetries, which can be described by algebraic structures (e.g. Lie groups). In many cases, observables in exactly solvable models are expressed in terms of special functions (e.g. orthogonal polynomials), whose analytic properties encode the symmetries of the system. The interaction between these elements can be presented schematically as follows:



SUMMARY

This article gives a peek at some of the results of the thesis "Algebraic Structures, Superintegrable Systems, and Orthogonal polynomials". The thesis won the 2016 CAP-DTP/WITP Thesis Prize, as well as the 2016 Doctoral Prize from the Canadian Mathematical Society.

Unravelling new exactly solvable and superintegrable models, new symmetries, new algebraic structures and their representations, as well as new families of orthogonal polynomials, and exploring their import to all the other fields of the above diagram is the leitmotiv of my thesis. The thesis is comprised of 28 articles written in collaboration with other physicists and mathematicians, and is concerned with the following topics:

1. The algebraic characterization of families of multivariate orthogonal functions and their applications to physics.
2. The study of the Bannai-Ito algebra and its relation with the Bannai-Ito hierarchy of univariate orthogonal polynomials, as well as its relation to novel families of exactly solvable and superintegrable quantum systems.
3. The determination of the link between quantum superintegrable systems with 2^{nd} order constants of motion and the recoupling of Lie algebra and superalgebra representations.
4. The study of the symmetries and algebraic structures associated to 2D and 3D Dunkl-type systems, which are governed by Hamiltonians involving reflection operators.
5. The algebraic characterization of matrix multi-orthogonal polynomials and their applications to squeezed-coherent states for finite oscillator models.

In the interest of brevity, I shall here touch upon a small subset of the novel results obtained in regards to the first two topics.

MULTIVARIATE ORTHOGONAL POLYNOMIALS AND APPLICATIONS

In a series of papers [1–3], we considered matrix elements of the unitary representations of the rotation, Lorentz and Euclidean groups on oscillator states. We showed that these matrix elements have the general form

$$< n_1, n_2, \ldots, n_d | U(g) | x_1, x_2, \ldots, x_d > \\ = \sqrt{\omega(x_1, x_2, \ldots, x_d)} P^{(g)}_{n_1, n_2, \ldots, n_d}(x_1, x_2, \ldots, x_d),$$

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where $P^{(g)}_{n_1,n_2,\ldots,n_d}(x_1,x_2,\ldots,x_d)$ are orthogonal polynomials in the discrete variables $x_i \in \{1, 2, \ldots\}$, where $\omega(x_1, x_2, \ldots, x_d)$ is their orthogonality weight, and where $U(g)$ stands for the unitary representation of the group element g. For the rotation and Lorentz groups, the polynomials were respectively identified as the multivariate Krawtchouk and Meixner polynomials. This physical interpretation involving the oscillator states allowed to completely characterize these polynomials, to derive new properties, and to cast them in a clear physical framework. In the case of the Euclidean group, the analysis led to the discovery and characterization of a new family of multivariate Charlier polynomials. As for direct physical applications, the 2-variable Meixner et Charlier polynomials were seen to arise as the exact solutions in discrete oscillator models that share the same *SU(2)* symmetry as their continuous analog; see for example [4]. The 2-variable Krawtchouk polynomials played a central role in the design of a two-dimensional spin lattice that exhibits a kind of perfect state transfer [5].

A DUNKL-DIRAC EQUATION AND THE BANNAI-ITO ALGEBRA

In [6], we considered the null-solutions of the so-called Dirac-Dunkl operator in $\mathbb{R}^3$ associated to the reflection group $\mathbb{Z}_2^3$. These null-solutions ψ satisfy the equation $\underline{D}\psi = 0$, where $\underline{D}$ is the Dirac-Dunkl operator defined as

$$\underline{D} = \sigma_1 T_1 + \sigma_2 T_2 + \sigma_3 T_3.$$

In the above, σ_i are the Pauli matrices and T_i are the Dunkl operators

$$T_i = \partial_i + \frac{\mu_i}{x_i}(1 - r_i),$$

where ∂_i is the derivative with respect to the coordinate x_i, where μ_1, μ_2, μ_3 are positive parameters and where r_i is the reflection operator in x_i, e.g. $r_1 f(x_1, x_2, x_3) = f(-x_1, x_2, x_3)$. As a result, this operator can be viewed as a three-parameter deformation of the Dirac operator in $\mathbb{R}^3$; its spherical component can similarly be interpreted as a three-parameter deformation of the spin-orbit Hamiltonian. We constructed a complete set of constants of motion that commute with $\underline{D}$ and showed that these symmetries, denoted by K_1, K_2, K_3 (with $[K_i, \underline{D}] = 0$ for $i = 1, 2, 3$) satisfy the Bannai-Ito algebra

$$\{K_1, K_2\} = K_3 + \delta_3, \{K_2, K_3\} = K_1 + \delta_1, \{K_3, K_1\} = K_3 + \delta_3,$$

where $\{A, B\}$ stands for the anticommutator, and where δ_1, δ_2, δ_3 are central elements (which are constants on the null-solutions ψ). We constructed an explicit basis for the null-solutions ψ involving Jacobi polynomials, and showed that these solutions transform irreducibly under the action of the Bannai-Ito algebra.

The Bannai-Ito algebra is one example of the novel algebraic structures that was uncovered in my thesis and related to several exactly solvable and superintegrable systems. As an example, this algebra was also seen to arise as the invariance algebra for a system three para-Bose oscillators [7].

CONCLUSION

In my thesis, I explored the deep interplay between exact solvability, symmetries, algebraic structures and their representations, and special functions, in particular orthogonal polynomials of one or many variables. There is no doubt to me that there is still much to explore in that area. Furthermore, one can expect that the novel algebraic structure exhibited in my thesis, in light of their naturalness, will emerge in other applications to mathematics or physics.

ACKNOWLEDGEMENTS

The author would like to acknowledge the financial support of the Natural Science and Engineering Research Council of Canada. The author would like to thank Luc Vinet for his outstanding supervision, as well as all of his co-authors.

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2016 STUDENT COMPETITIONS / *COMPÉTITIONS ÉTUDIANTES 2016*

(SEE EXTENDED ABSTRACTS OF THE WINNERS ON PAGES 109-125 PLUS PHOTOS ON PAGE 108 /
VOIR LES RÉSUMÉS DES GAGNANTS AUX PAGES 109-125 ET PHOTOGRAPHIES À LA PAGE 108)

The Canadian Association of Physicists has established these awards to recognize student members giving the best oral and poster research presentations at the annual CAP Congress. Up to three awards in each category, each consisting of a certificate of recognition and a cash prize, are made each year. In addition, a number of CAP Divisions offer prizes for the best student presentations at the divisional level. Eligibility, selection procedure, and selection criteria for the competitions are available through the Congress website each year.

L'Association canadienne des physiciens et physiciennes a créé ces prix afin de récompenser les membres étudiants auteurs des meilleures communications au congrès annuel. Elle décerne tous les ans un maximum de trois prix dans chaque catégorie, chacun consistant d'un certificat de mérite et d'une somme. De plus, plusieurs divisions offrent des prix pour leurs meilleures présentations étudiantes. Admissibilité, modalités et critères de sélection pour les prix sont sur le site web de l'ACP.

CAP DIVISION PRIZES / *PRIX DES DIVISIONS DE L'ACP*

Division prizes included a cash prize of $200 for first, $100 for second, and $50 for third. /
Les prix des divisions incluent une somme de 200 $ (1er), 100 $ (2e) et 50 $ (3e).

ATMOSPHERIC AND SPACE PHYSICS / *PHYSIQUE ATMOSPHÉRIQUE ET DE L'ESPACE*

PLACEMENT	NAME/AFFILIATION
Oral-First	Bing Yang, U. of Calgary
Oral-Second	David Themens, U. of New Brunswick

ATOMIC, MOLECULAR AND OPTICAL PHYSICS, CANADA / *PHYSIQUE ATOMIQUE, MOLÉCULAIRE ET PHOTONIQUE, CANADA*

PLACEMENT	NAME/AFFILIATION
Oral-First	Rebecca Saaltink, U. of Ottawa
Oral-Second	Matthew Runyon, U. of Ottawa
Oral-Third	Christopher DiLoreto, U. of Windsor
Poster-First	Parisa Zarkeshian, U. of Calgary
Poster-Second	Domenico Bongiovanni, INRS

CONDENSED MATTER AND MATERIALS PHYSICS / *PHYSIQUE DE LA MATIÈRE CONDENSÉE ET MATÉRIAUX*

PLACEMENT	NAME/AFFILIATION
Oral-First	Carolyn Cadogan, U. of Western Ont.
Oral-Second (tie)	Andrew James Macdonald, U. of British Columbia
Oral-Second (tie)	Ye Li, U. of Western Ontario
Poster-First	Joyprokash Chakrabartty, U. du Québec / INRS
Poster-Second	Christopher Pashartis, McMaster U.

INSTRUMENTATION AND MEASUREMENT / *INSTRUMENTS ET MESURES*

PLACEMENT	NAME/AFFILIATION
Best Overall	Ryan Bolen, U. of Ottawa

NUCLEAR PHYSICS / *PHYSIQUE NUCLÉAIRE*

PLACEMENT	NAME/AFFILIATION
Oral-First	Steffen Cruz, U. of British Columbia
Oral-Second	Christina Burbadge, U. of Guelph

PARTICLE PHYSICS / *PHYSIQUE DES PARTICULES*

PLACEMENT	NAME/AFFILIATION
Oral-First	Jennifer Mauel, Queen's U.
Oral-Second	Chanpreet Amole, Queen's U.
Oral-Third	Paul Smith, U. of Saskatchewan

PHYSICS IN MEDICINE AND BIOLOGY / *PHYSIQUE EN MÉDECINE ET EN BIOLOGIE*

PLACEMENT	NAME/AFFILIATION
Oral-First	David Sean, U. of Ottawa
Oral-Second	Qinrong Zhang, U. of Waterloo
Oral-Third	Sebastian Himbert, McMaster U.
Poster-First	Benjamin Barlow, U. of Ottawa

THEORETICAL PHYSICS / *PHYSIQUE THÉORIQUE*

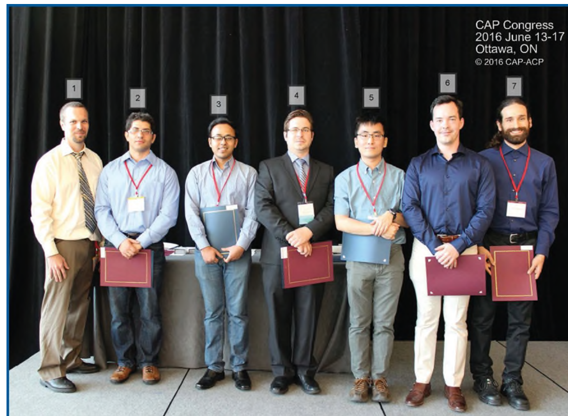
PLACEMENT	NAME/AFFILIATION
Oral-First	Robie Hennigar, U. of Waterloo
Oral-Second	Alexander Smith, U. of Waterloo
Oral-Third	Michelle Przedborski, Brock U.
Poster-First	Keith Ng, U. of Waterloo

Congratulations

CAP AWARDS - POSTER

Poster prizes included a certificate of recognition and a cash award of $400, $200, and $100 respectively for the top three placements sponsored by the CAP.

Placement	Name/Affiliation
First	Brian Kootte, U. of Manitoba / TRIUMF
Second	Benjamin Barlow, U. of Ottawa
Third	Alexandre Le Blanc, Laurentian U.
Finalist-HM	Ryan Bolen, U. of Ottawa
Finalist-HM	Domenico Bongiovanni, INRS
Finalist-HM	Joyprokash Chakrabartty, U. du Québec / INRS



2016 CAP and Division Poster Award Recipients: 1) Ryan Bolen, 2) Domenico Bongiovanni, 3) Joyprokash Chakrabartty, 4) Benjamin Barlow, 5) Keith Ng, 6) Alexandre Le Blanc, 7) Brian Kootte. Absent from the photo: Parisa Zarkeshian, Christopher Pashartis.

CAP AWARDS - ORAL PRESENTATIONS

Oral prizes included a certificate of recognition, and a cash award of $400, $200, and $100 respectively for the top three placements sponsored by Wiley. Wiley also offered book prizes to each of the eight finalists.

Placement	Name/Affiliation
First	David Sean, U. of Ottawa
Second	Jennifer Mauel, Queen's U.
Third	Rebecca Saaltink, U. of Ottawa
Finalist-HM	Carolyn Cadogan, U. of Western Ontario
Finalist-HM	Steffen Cruz, U. of British Columbia
Finalist-HM	Robie Hennigar, U. of Waterloo
Finalist-HM	Ye Li, U. of Western Ontario
Finalist-HM	Bing Yang, U. of Calgary

2016 CAP and Division Oral Award Recipients: 1) Alexander Smith, 2) Robie Hennigar, 3) Michelle Przedborski, 4) Paul Smith, 5) Bing Yang, 6) Chanpreet Amole, 7) Jennifer Mauel, 8) Matthew Runyon, 9) Christopher DiLoreto, 10) Andrew James Macdonald, 11) Rebecca Saaltink, 12) Steffen Cruz, 13) Sebastian Himbert, 14) Carolyn Cadogan, 15) Qinrong Zhang, 16) Ye Li, 17) David Sean, 18) Christina Burbadge. Absent from the photo: David Themens.

Thanks to the CAP competition sponsor / *Merci au commanditaire de la compétition de l'ACP*:

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and to the CAP's Vice-President Elect at that time, Dr. Stephen Pistorius of the University of Manitoba and CancerCare Manitoba, and all of the judges for their extraordinary efforts in organizing this event. Our thanks are also extended to all competitors.

The winners of the 2016 CAP Best Student Presentation Competition at the CAP Annual Congress, 2016 June 13-17, in Ottawa are listed on pages 107-108. The extended abstracts of those winners of the CAP prizes who submitted them for publication are reproduced below. Ed.

COARSE-GRAINED SIMULATIONS OF HIGHLY DRIVEN DNA TRANSLOCATION FROM A CONFINING NANOTUBE

BY DAVID SEAN AND GARY W. SLATER

Consider this brain teaser: How do you to pass a large knitted blanket to your cold friend waiting in a locked room where the only possible passage is a small keyhole in the door? The answer: simply find one of the two ends of the yarn and slowly thread it through the keyhole. As the blanket unravels on one side of the door it can be reconstructed on the other.

Entropy ensures that a long DNA chain stays as a random disordered mess in a liquid. Passing a long polymer like DNA from one side of a membrane to the other via a nm-scale hole can at first seem impossible. But much like the passage of the knitted blanket through the keyhole, a large DNA molecule can realize the "impossible" by simply unraveling itself. Since DNA is charged in solution, this process can be driven via an electric field.

Imagine now that salt ions are present in the solution. These charged ions will also be driven to transit through the small opening, resulting in an ionic countercurrent that can be measured. Since the dividing membrane is electrically insulating, the electric field lines converge at the small hole and the measured conductivity is extremely sensitive to what is happening near the so-called *nanopore*. The passage of the DNA molecule will impede the ionic passage for the duration of the DNA *translocation* event. In the lab, this can be observed as a sudden drop in the electrical conductivity between the two chambers. Experimental translocation data is typically extracted from the duration and amplitude of a recorded drop in the measured current readout [1]. The duration of this current blockage can provide information on the molecule such as its total curvilinear length. In this short report, we present computational work on using DNA translocation for applications where the focus is on determining the length of a piece of DNA.

SUMMARY

We study the effect of pre-confining DNA in a small tube prior to driven translocation. Computer simulations are presented together with a theoretical Tension-Propagation model.

There are many applications which require finding the length of the DNA molecules present in an unknown sample. For example, forensic DNA *fingerprinting* works by breaking a long DNA molecule into smaller fragments using restriction enzymes that cleave it at sequence-specific sites. The length distribution of these smaller DNA fragments constitutes the fingerprint. Traditional *macroscopic* sizing techniques relies on the separation of these smaller pieces at a *population*-level. That is, a single DNA molecule may need to be amplified multiple times in order to create a population of DNAs which will later be fragmented and size-separated.

Nanopore translocation techniques, as described above, can be integrated into portable lab-on-a-chip devices. These can be much faster, cheaper and easier to operate than traditional methods—and could potentially only require a single DNA molecule!

Oddly, with a sample solution where all the DNA molecules are identical in size, experimental distributions of translocation times are found to be surprisingly wide. The reason for this is an example of *molecular individualism*, an expression coined by Pierre-Gilles de Gennes [2].

Figure 1a depicts a handful of possible DNA shapes—or *conformations*—at the moment when the translocation process begins (the first monomer is inside the pore). As is obvious from the figure, we are using here a rather coarse-grained representation of DNA—a simple chain of beads and springs. The generic polymer model of $N = 100$ beads is described in more details in ref [3]. The focusing of the electric field inside the pore completely dwarves its effect outside the pore. This permits us to simplify the problem further: the effect of

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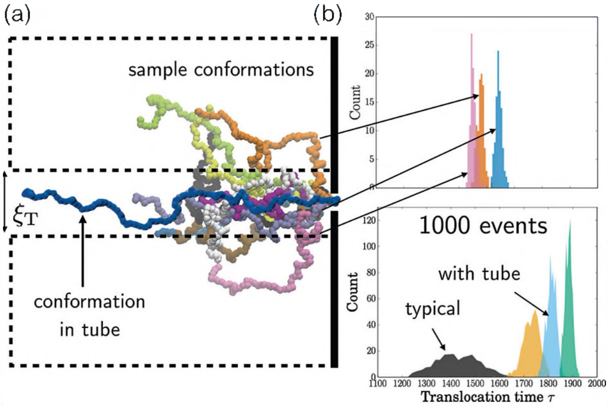

Fig. 1 (a) Placing a tube (depicted as dashed lines) removes many of the conformations found in the absence of such a tube. (b) Simulation histograms of the translocation time. Top: Three tube-free cases obtained by using the same initial conformations for multiple events. Bottom: results arising from different conformations using a typical translocation setup (no tube) and results from using three different infinitely long tubes.

the driving field is modeled as a force only applied to the beads present inside the nanopore.

We show in Fig. 1b the corresponding histograms of translocation times. The top panel is generated by repeating the simulation with the same conformation, but with different Brownian trajectories. A remarkable feature is how the different distributions are centred about their own mean translocation times. Since the translocation process occurs much faster than the time it takes for the polymer to relax (typically by two orders of magnitude), the exact positions of all the beads at the onset of translocation is a determining factor in the resulting transit time. In the lab, one cannot explicitly control for the shape of the DNA molecule once the first bead enters the pore. The resulting histograms contain a large mix of possible shapes yielding a rather wide distribution of translocation times for what is in essence a group of chemically-identical molecules! Indeed, the bottom panel of Fig. 1b shows how wide the distributions can become. Thus one way to tighten them would be to somehow limit the range of initial DNA conformations. In Fig. 1a there is a schematic of a confining tube which we use as a way to limit the possible initial conformations. We will assume that this hypothetical tube is made of a porous material such that it does not significantly affect the flow of ions or distort the field lines.

We report here the use of long (longer than the polymer) confining tube characterized only by its diameter ξ_T. By construction, the tube will limit the range of possible conformations, which by virtue of our preceding argument, should reduce the width of the distribution of translocation times.

We first generate a DNA conformation that has its first bead inside the nanopore. The presence of the tube imposes a hard cutoff $\rho = \xi_T/2$ in the radial positions of the remaining beads. For entropic reasons, a polymer chain does not like to be compressed. When we impose radial restrictions, it reacts by swelling outwards in the axial direction. As a side-effect, a thin tube will tend to squeeze out the DNA away in the axial direction. This means that the remaining monomers will on average be positioned further from the pore and will need to travel longer to translocate to the other side, as shown in the insets of Fig. 2a.

Although it may seem that this "distancing" effect alone should yield longer translocation times, there is another—perhaps subtler—contributing factor relating to the translocation *rate*. Let us investigate this according to what is known as the Tension-Propagation Theory [4].

In these out-of-equilibrium dynamics of translocation, the driving force causes a *tension* that propagates down the polymer (see red beads in Fig. 2b). If we neglect the crowding of monomers on the *trans*-side and friction in the nanopore—which contribute to minor corrections—a force-balance argument can be made to show that the instantaneous translocation rate is proportional to the number of monomers that feel this tension.

Consider the forces acting on the bead inside the pore in Fig. 2b. In the overdamped limit, the driving force F_d applied to this bead is balanced by the drag force of all moving beads under tension (coloured in red). Every bead contributes to a viscous force $-\zeta v$, with ζ the bead's friction coefficient and v the velocity. If there are k beads moving together as shown in Fig. 2b (red beads), then the total friction resisting the applied force is $-k\zeta v$ which enables us to find the translocation rate (or terminal velocity) of $v = F_d/k\zeta$. Since the driving force F_d and the friction coefficient ζ are known quantities, the resulting rate can be determined for every step of the process if we can find how many beads are affected by the applied force, i.e., how tension propagates.

Note that the beads outside the tension front do not (yet) contribute to this resistance. In fact, these beads do not even know that translocation has started. Since we consider the limit where the process is highly driven, a geometrical argument can be made to estimate the number of monomers under tension once the tension front reaches a specific bead. Figure 2b shows how the initial position of the i^{th} bead can be used to estimate the number of beads under tension once the tension front reaches it. Since the monomers under tension form a taught segment, the distance R_i between the i^{th} bead and the pore can be used to find the number of moving monomers (and the translocation rate) once the tension front reaches it.

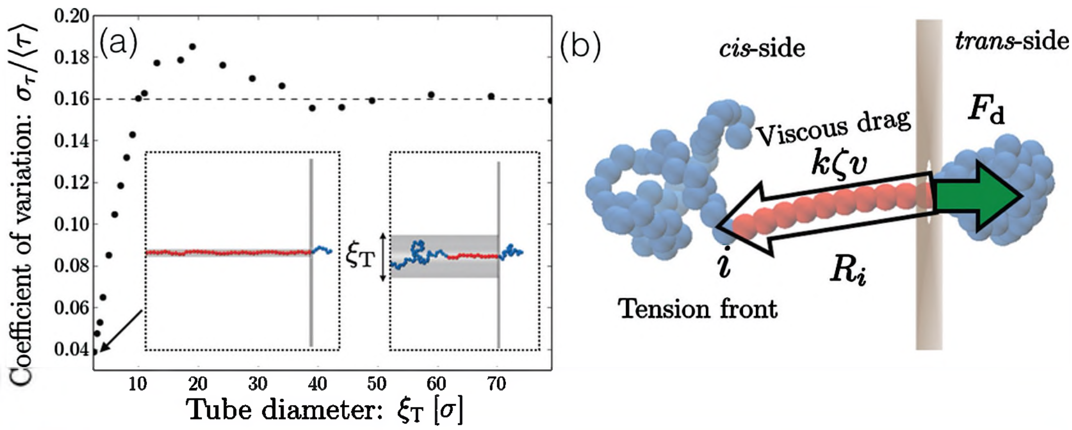

Fig. 2 (a) The coefficient of variation $\sigma_\tau/\langle\tau\rangle$ plotted for different tube radii. (b) A free-body diagram centred on the bead inside the nanopore. The drag from the beads under tension (red) opposes the force applied in the pore F_d. The i^{th} bead's initial distance R_i is used to find the amount of beads under driven motion (red) once the tension front has reached it.

This picture highlights why the initial conformations matter so much in determining the total translocation time: the initial positions essentially determine what values of viscous damping is felt by the polymer during translocation. Thin tubes will yield longer translocation events because it also causes the system to sample what is effectively a higher amount of viscous damping. Imagine pulling a heavy 1 km long chain lined-up straight on a road, versus pulling a similar chain but which is instead neatly coiled in a pile. Displacing the lined-up chain would require moving *all* the links in unison, whereas in the coiled version, you would be able to move the chain tip for a fair amount before the accumulated drag would become overwhelming.

The total translocation time τ can be determined by integrating the rate. This is a two-step process: there is the time needed to propagate to the last bead and a time for the final retraction [3]. Combining them gives a total translocation time which can be written as

$$\tau = \frac{\zeta}{F_d}\int_0^N R_i \, di,$$

where the information in the initial conformation is completely captured by the list of initial monomer distances R_i (see Fig. 2b). Averaging the above, we obtain the mean translocation time $\langle\tau\rangle = \zeta N\langle R\rangle F_d$. Note that small tube diameters not only reduce the standard-deviation σ_τ because they limit conformations, but also *increase* the mean translocation time $\langle\tau\rangle$ by pushing the beads away from the pore and increasing the friction. These two effects work together in reducing the coefficient of variation $\sigma_\tau/\langle\tau\rangle$ four-fold, as shown in Fig. 2a. When using a given mixture of multiple DNA fragments, decreasing the coefficient of variation $\sigma_\tau/\langle\tau\rangle$ means that DNA sizing can be obtained a higher resolution.

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THE GIOVE DETECTOR: HIGH SENSITIVITY GERMANIUM SPECTROSCOPY AT SHALLOW DEPTH

BY JENNIFER MAUEL IN ASSOCIATION WITH THE MAX-PLANCK-INSTITUT FÜR KERNPHYSIK, HEIDELBERG

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High purity germanium crystals can be manufactured into gamma ray detectors with excellent energy resolution, and are therefore very well-suited to measuring trace amounts of radioactivity in materials. Germanium spectroscopy has become a vital tool to screen materials for radioactivity for use in rare-event particle physics experiments, such as dark matter, neutrinoless double beta decay, and solar neutrino searches.

Experiments using this technology to reach their background reduction targets include the GERDA search for neutrinoless double beta decay and the XENON dark matter project operating at Gran Sasso National Laboratory (LNGS) in Italy [1,2]. Typically these experiments require a very low background from Uranium and Thorium chains, therefore germanium detectors performing material screening must be able to detect concentrations of radio-impurities in construction materials at the μBq/kg level. This is usually achieved by operating screening facilities deep underground where there is substantial overburden to shield from cosmic rays and their secondary particles.

Currently the most sensitive germanium detectors in operation are the GeMPI detectors at LNGS, developed by the Max-Planck-Institut für Kernphysik (MPIK) in Heidelberg, Germany. With approximately a 3800 m of water equivalent (m w.e.) overburden, the GeMPI detectors have been shown to achieve sensitivities in the 10 $\mu Bqkg^{-1}$ range for U and Th isotopes. However it can be inconvenient and time-consuming for experiments to rely on these detectors. Experiments must ship all their materials to LNGS for measurements, which can take up to 100 days of counting time to collect sufficient statistics. The scarceness of adequate material screening facilities makes it difficult to serve the needs of many experiments simultaneously [3].

SUMMARY

The GIOVE detector is a highly sensitive germanium detector used for material screening in rare-event particle physics experiments. Design principles of the shield and the results of preliminary material screening tests are discussed.

For this reason, effort has been put into developing germanium spectrometers that can reach similar sensitivities as the GeMPI detectors, but which operate at shallow depths where there is minimal shielding from cosmic ray particles. The Germanium-Inner-Outer-Veto (GIOVE) detector, located in the low-level laboratory at MPIK, is at the forefront of these efforts. With a mere 15 m w.e. overburden, GIOVE has been shown to achieve sensitivities in the 100 $\mu Bqkg^{-1}$ range from U and Th in typical γ-ray sample screening measurements [3]. The sensitivity levels demonstrated by GIOVE mark a breakthrough in shallow depth germanium spectroscopy, indicating that it may be possible in the near future for such detectors to reach the sensitivities available at deep underground counting facilities.

THE GIOVE SHIELD

Background Sources in GIOVE

The GIOVE shield has been developed to reduce all major sources of background in the detector. There are four major contributions to background in GIOVE: cosmic ray muons, environmental radiation (from the walls and shield materials), neutrons from (α, n) reactions or spontaneous fission of natural U and Th isotopes, and neutrons from cosmic rays - the first two components being the most dominant background sources.

Muons, produced by cosmic rays interacting with the atmosphere, contribute to background in GIOVE by a number of different mechanisms. First, they produce bremsstrahlung photons and electrons when they interact with high density materials such as the lab walls or detector materials. Muons can also produce neutrons by muon capture (dominant at lower muon energies), photonuclear interactions, and spallation (high muon energies); the former being the most dominant source of muonic neutron production in the shallow depth lab. Furthermore, these neutrons can produce photons and electrons which can be captured by germanium atoms. Following capture, the germanium ions may become excited and lines will be seen in the energy spectrum of the detector. The de-excitation lines of ^{71m}Ge, ^{73m}Ge, and ^{75m}Ge due to neutron capture on the crystal are the most problematic neutron-induced background component seen in the detector [3].

Environmental radiation is a second major background source, caused by radio-impurities in the lab surroundings and the shield layers themselves. The shield layers have been carefully selected for high levels of radio-purity, however even trace concentrations of some radioisotopes in the materials can pose a problem as the lines can be seen directly in the detector. Radioactivity in the lab walls, in particular the 2.6 MeV γ-line due to decays of the ^{232}Th daughter nuclide ^{208}Tl, can also be seen directly in the detector.

Other minor sources of neutrons include those from (α, n) reactions and spontaneous fission of natural U and Th isotopes, however this effect is almost negligible at shallow depths. Neutrons from the hadronic component of cosmic rays also contribute a small amount of background, but this effect can largely be shielded by the 5.3 m rock and soil overburden in the lab.

Shield Design Principles

In order to address the various background sources outlined above, the shield has been designed with both active and passive shield components to achieve the necessary background suppression targets. The main purpose of GIOVE is to achieve exceptional sensitivity in the 100 μBqkg^{-1} range at its shallow-depth location. With the 15 m w.e. overburden, the muon flux in the low-level lab is reduced merely by a factor of 2 to 3, the integral flux being approximately 90 m^{-2} s^{-1} [4]. This is a small reduction in comparison to deep underground locations such as LNGS, where the muon flux is reduced by a factor of 10^6. Therefore a cosmic ray muon veto efficiency of $\geq$99% is necessary in order to avoid observation of bremsstrahlung radiation resulting from muons incident on high density materials. This is dealt with by the active component of the shield known as the inner and outer muon veto system, which is described in greater detail below.

The second background suppression target requires attenuation of the neutron-induced background component, mainly delayed de-excitation γ-lines of meta-stable Ge isomers, to the greatest possible extent. The three meta-stable Ge isotopes mentioned previously have lifetimes longer than the muon veto, and therefore this source of background must be addressed by neutron absorption rather than active shielding methods [3]. In order to prevent neutrons from reaching the Ge diode, neutron-absorbing layers make up part of the passive shield. The remainder of the passive shield is dedicated to suppressing radiation from the lab environment and radio-impurities in the shield layers.

Figure 1 depicts the side-view of GIOVE, which consists of four types of shield layers surrounding the Ge diode inside the copper sample chamber. The plastic scintillator layers make up the active component of the shield, known as the inner and outer muon veto system to which GIOVE can attribute its name. Highly sensitive PMTs installed in both scintillator layers detect charged particles passing through the setup, and data collection is stopped for about 300 μs when a muon event is registered. This ensures that the resulting bremsstrahlung photons and electrons are not seen in the detector. Plastic scintillator (type EJ-200) was chosen because of its high photon yield and fast signal response. These characteristics are especially important because it ensures good discrimination between muon signals and environmental gamma events, which minimizes the amount of dead time in the detector due to accidental gamma triggers.

The two-layer structure of the muon veto system is advantageous because muons passing undetected through the outer plates, through the outer edges and corners or depositing energy just below the sensitive threshold, still have a chance of being detected by the inner plates. The result of the inner-outer veto system is a $\geq$99% muon tagging efficiency with an acceptable dead time fraction of $\sim$2%, greatly minimizing much of the muon-induced background component in the setup.

The passive shield layers consist of three 5 cm layers of low-activity lead, three 5cm layers of boron-loaded polyethylene and a 7 cm layer of high purity copper surrounding the sample chamber. The Pb layers are dedicated to suppressing environmental radiation due to lead's high mass density, relatively high radiopurity, and low cost. A total of 15 cm of Pb shielding ensures that the shield is compact enough to keep muonic neutron production in these layers low, but large enough to ensure sufficient attenuation of the 2.6 MeV γ-line emitted by the lab walls. High purity copper surrounds the sample chamber, providing a final layer to suppress any radio-impurities in Pb or B. The Cu layer has been stored with minimal sea-level exposure following manufacture to limit cosmogenic activation.

The remainder of the passive shield consists of three layers of 3-10% boron-loaded polyethylene (PE), which are dedicated to attenuating neutrons produced by muons interacting with the lead or other sources. Polyethylene is a neutron moderator, and therefore slows neutrons down to thermal energies so that they can be absorbed by a neutron capture target. The capture target must be a material with a large thermal neutron capture cross-section, in this case boron was deemed most suitable because of its relatively high radiopurity and a large thermal neutron capture cross section of 767 b [5]. As shown in Fig. 1, the higher boron-loaded polyethylene plates are positioned on the outer layers of the detector due to potential radio-impurities in B. It was found that greater than 3% boron loading in polyethylene provides only a small improvement in neutron absorption [3]. As a result of the neutron attenuating layers, the neutron flux in the detector has been reduced by $\sim$70%. This in combination with the inner-outer muon veto system allows GIOVE to reach integral count rates that are typically obtained at moderately deep underground sites of several 100 m w.e.

Naturally, all materials used to construct the shield were selected to ensure the highest possible levels of radiopurity throughout the setup. The target for line background rates caused by primordial radionuclides is less than 1 d^{-1} in the Ge detector, which has been achieved in the current GIOVE

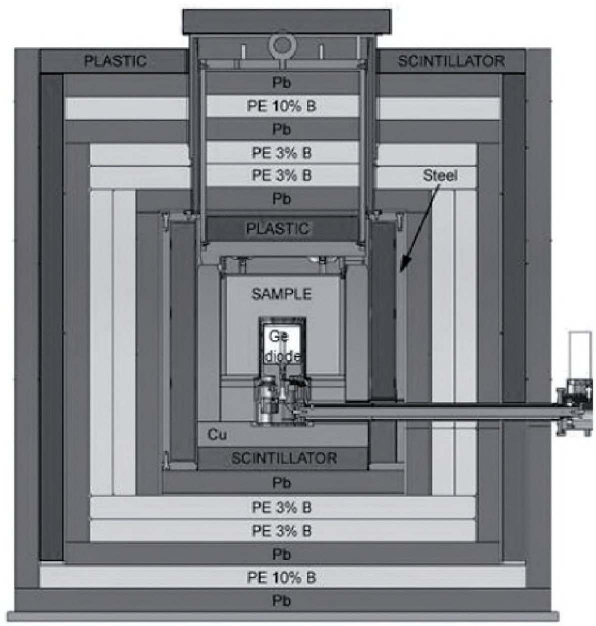

Fig. 1 Cross-section of the GIOVE shield.

set-up. Electron-beam welding and electropolishing has been applied wherever possible during construction to ensure clean surface finishes, and final assembly of the shield took place in the clean room conditions of the low level lab. However despite all efforts to minimize radio-impurities during material selection, it may be possible to improve the sensitivity of the detector if materials with higher radio-purity can be found to replace the current shield layers. This is an area of ongoing investigation. In particular, we are exploring alternatives to borated polyethylene as a neutron capture target and Pb as a shield against environmental radiation due to potential radio-impurities in both materials.

CONCLUDING REMARKS AND FUTURE WORK

GIOVE is a promising development in shallow-depth germanium spectroscopy as it has been shown to attain material screening sensitivities formerly only possible at moderately deep underground sites. The unique shield design of GIOVE, combining passive and active shielding techniques allow the detector to achieve sensitivities in the 100 μBqkg^{-1} range for primordial U and Th traces in γ-ray screening measurements. This is just one order of magnitude greater than what is achieved by the GeMPI detectors at LNGS, where a 3800 m w.e. overburden suppresses the muon flux by a factor of 10^6.

The inner and outer muon veto system makes up the active component of the shield, consisting of two plastic scintillator plates positioned on the inner and outer layers of the shield. At its shallow depth location, GIOVE requires a muon veto efficiency of $\geq$99%, which has been achieved in part due to the unique two-layer structure of the scintillator plates.

The passive shield layers include 15 cm Pb and 7 cm Cu of low intrinsic radioactivity, which are dedicated to shielding from radiation in the lab environment and from radio-impurities in the shield layers. Three 5 cm layers of borated polyethylene serve as a neutron moderator (PE) and capture target (B). These neutron attenuating layers have been shown to reduce the neutron flux in the detector by approximately 70%.

In order to further optimize the shield design, alternative shield materials are currently being investigated to improve the radio-purity and neutron attenuating properties of the current GIOVE setup. In particular, materials with high mass density and radio-purity are being considered as alternatives to Pb, and alternate neutron moderators and absorbers are being explored to further minimize radio-impurities and increase neutron absorption. In addition to new materials, new configurations of the existing shield layers are also being tested in simulations. Preliminary results suggest that it may be possible to further improve the sensitivity of GIOVE in the future.

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SUPER-CRITICAL PHASEMATCHING FOR GENERATION OF STRUCTURED LIGHT BEAMS

BY REBECCA SAALTINK, LAMBERT GINER, ROBERT W. BOYD, EBRAHIM KARIMI, AND JEFF S. LUNDEEN

Radially and azimuthally polarized light beams are characterized by particular non-uniform polarization patterns. They have attracted recent interest for their properties and uses in applied and fundamental optics. A radial polarization points to a light beam's central propagation direction (i.e. the beam axis) everywhere in the beam's spatial profile. An azimuthal polarization is everywhere orthogonal to the radial polarization. That is, it is tangential to a circle centered on the beam axis [1]. Photon pairs with these polarizations have applications in quantum information, such as alignment-free quantum key distribution [2] and protocols to carry multiple bits of information on one photon (e.g. superdense coding) [3]. We present a method to directly produce, through spontaneous parametric down-conversion (SPDC), photon pairs with radial and azimuthal polarizations.

In SPDC, a pump photon is absorbed and two lower-frequency photons, the signal and idler, are produced such that energy and momentum are conserved (i.e. phasematching). These photons may be produced in the same direction as the pump beam, in collinear phasematching, and may have polarizations that are parallel (Type I) or orthogonal (Type II). In our new geometry, the pump beam is a Bessel-Gauss beam, which we have modeled as a distribution of Gaussian beams propagating along the surface of a cone towards its apex. This cone is centered on the crystal axis, which is parallel to the central pump propagation direction. The opening angle of this cone is set so that each Gaussian pump beam in the pump distribution meets the conditions needed for phasematching. Bessel-Gauss beams have been used to pump the opposite process, second-harmonic generation, but in these cases the phasematching conditions were non-critical and therefore distinct from the phasematching conditions considered here [4,5].

SUMMARY

This paper presents a novel geometry for spontaneous parametric down-conversion that will directly produce photon pairs with radial and azimuthal polarizations.

SIMULATION RESULTS

We have simulated the probability densities for the signal and idler photon for Type II degenerate, collinear phasematching from 405 nm to 810 nm, as shown in Fig. 1. The phasematching is simulated in a 500 μm thick β-barium-borate (BBO) nonlinear optical crystal. The opening angle of the pump beam is set to 41.8°, which is the degenerate collinear phasematching angle in BBO for a 405 nm pump. This pump beam is then strongly non-paraxial, and so it was convenient to model the pump beam as a distribution of paraxial Gaussian sources, each with central **k**-vector $\mathbf{k}_p^0(\varphi_p)$, where φ_p is the azimuthal angle of spherical coordinates. We can then calculate the complex amplitude for the signal and idler to have **k**-vectors $\mathbf{k}_s$ and $\mathbf{k}_i$, respectively, and sum these amplitudes for each Gaussian beam in the pump distribution. These calculations follow those outlined by Boeuf *et al.* [6]. Summing and squaring the amplitudes for each signal(idler) emission direction gives the marginal probability density $P(\mathbf{k}_{s(i)})$ to produce a signal(idler) with k-vector $\mathbf{k}_{s(i)}$. We have plotted these marginal probability densities ($P(\mathbf{k}_s)$, $P(\mathbf{k}_i)$) for the signal and idler photons in Fig. 1.

CONCLUSION

We have demonstrated a novel method to directly produce radially and azimuthally polarized photon pairs. These unique polarization states have applications in quantum information and quantum metrology, and are opening new research directions in these fields.

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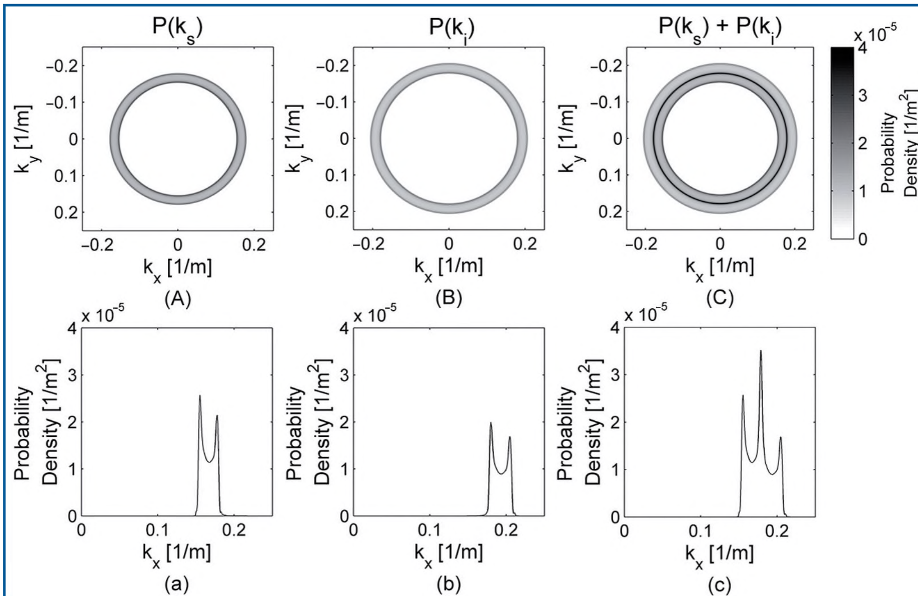

Fig. 1 Marginal probability density (P($\mathbf{k}_s$), P($\mathbf{k}_i$)) for Type II degenerate down-conversion. The pump cone half-angle is 41.8° in a 500 μm thick BBO crystal. The pump beam wavelength is 405 nm and the signal and idler wavelengths are 810 nm. Plots (A), (B), and (C) give (A) the probability density of generating a signal photon at $\mathbf{k}_s$, (B) the probability density of generating an idler photon at $\mathbf{k}_i$, and (c) P($\mathbf{k}_s$) + P($\mathbf{k}_i$), which is proportional to the photon flux. Plots (a), (b), and (c) are produced from plots (A), (B), and (C), respectively, by plotting along $k_y = 0$.

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USING ELECTRON COOLING TO HELP WEIGH EXOTIC NUCLEI - PROGRESS ON TITAN'S COOLER PENNING TRAP (CPET)

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The formation of approximately half of the elements in the universe which are heavier than iron is understood to occur in extremely neutron-rich environments in what is called the "rapid neutron capture process" or "*r*-process"[1]. In a matter of seconds, nuclei undergo successive neutron captures to produce heavy, but extremely unstable, neutron-rich isotopes which eventually beta-decay into the higher mass elements that we observe on Earth. The site of this process, however, remains a point of contention. Popular candidate astrophysical sites include core-collapse supernovae and neutron star mergers[2].

The Isotope Separator and ACcelerator (ISAC) facility located at TRIUMF, in Vancouver, BC, Canada is able to synthesize some of the isotopes which directly impact the reaction pathways in these extreme environments, as well as those which can help to constrain our theoretical understanding of the isotopes that are presently unfeasible to produce with current technology.

TITAN AS THE SOLUTION

In order to calculate the nuclear reaction pathways which determine the present day abundances of the heavy elements in the universe, the masses of nuclei need to be known to high precision[2-4]. Masses of short-lived nuclei are also critical inputs for theorists striving to uncover the fundamental structure of the nucleus[4-6]. TRIUMF's Ion Trap for Atomic and Nuclear science (TITAN) specializes in determining the masses of these nuclei to high precision (see Fig. 1). Mass uncertainties of less than 10^{-6} are needed to study nuclear structure[4], and uncertainties of 10^{-7} or better are required to constrain r-process models[3,4].

SUMMARY

We are commissioning a new trap for cooling short-lived isotopes relevant to astrophysics in order to quickly perform high-precision mass spectrometry.

MASS MEASUREMENTS AT TITAN

At TITAN we employ Penning Trap Mass Spectrometry (PTMS) to measure the masses of short-lived isotopes produced in nuclear reactions. This involves measuring the cyclotron frequency of a series of trapped ions, as they orbit in the magnetic field of the trap due to the Lorentz force. The mass can be extracted due to the fact that the cyclotron frequency is inversely proportional to the inertial mass of the ion as seen in the expression $f = \frac{qB}{2\pi m}$, where f is the orbital frequency, q is the charge of the ion, B is the magnitude of the magnetic field, and m is the mass. By applying a range of excitation frequencies near the cyclotron frequency, we produce a resonance curve with the maximal energy being transferred to the ion at the resonant frequency. We observe this energy transfer as a reduction in the time-of-flight to a detector when the ion is ejected from the trap.

HIGHLY CHARGED IONS AND THE NEED TO COOL

Since the precision of a Penning trap mass measurement scales linearly with the charge of the ion, charge breeding (stripping additional electrons from the singly-charged ions) can be employed to enhance the precision of these measurements. The gain in precision achieved by charge breeding radioactive ions is given by

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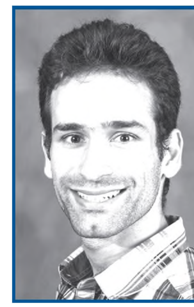
Matthew Foster: University of Surrey.
Renee Klawitter and Stefan Paul: University of Heidelberg.



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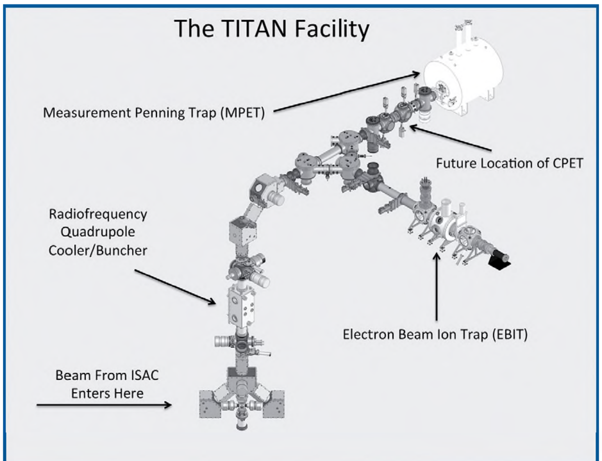

Fig. 1 The TITAN facility specializes in measuring the masses of short-lived isotopes to high precision. Beams of short-lived isotopes enter at the bottom left and are cooled and bunched in a helium-filled radiofrequency quadrupole trap. To enhance the precision, ions can then be charge-bred in the EBIT. When fully operational, the Cooler Penning Trap (CPET) will be installed in front of MPET to cool the charge-bred ions prior to mass measurement.

$$G_{HCI} = q\sqrt{2^{-\frac{t_{CB}}{t_{1/2}}}\eta_{pop}\epsilon},$$

where t_{CB} is the charge breeding time, $t_{1/2}$ is the half-life of the ion, η_{pop} is the fraction of ions bred to the desired charge state, and ϵ is a term relating to the efficiencies of charge breeding [7]. Therefore, prior to mass measurement at TITAN, we use an Electron Beam Ion Trap (EBIT) to strip additional electrons from the singly charged ions delivered to TITAN from ISAC. These charge-bred ions have been used successfully to measure the masses of a variety of nuclei (e.g. [8,9]).

However, the charge breeding process inside the EBIT has been found to increase the energy spread of the ion bunch sent to the measurement Penning trap to $\sim$30 eV per charge state. This negatively impacts the precision by reducing the injection efficiency of the valuable radioactive beam into the measurement trap and by spreading out the time-of-flight resonance.

SOLUTION: THE COOLER PENNING TRAP (CPET)

In order to cool the charge-bred ions down to 1 eV per charge state prior to mass measurement, we are commissioning a Cooler PEnning Trap (CPET). If hot charged particles are trapped in the same spatial region as cold charged particles, they will interact via the Coulomb interaction and exchange kinetic energy. In this way, we plan to use a plasma of electrons to sympathetically cool the short-lived, highly charged ions. Although many of the ions of interest at ISAC have half-lives in the range of only tens of milliseconds, it has been predicted that we can sufficiently cool many of these isotopes before they decay. Moreover, the rate of recombination of ions with the electron plasma should be small compared to our cooling times [10].

CPET is composed of a magnetic field aligned along the path of the ions and a series of trapping electrodes. The magnetic field radially confines charged particles to the central axis of the trap, and DC voltages applied to the electrodes confine them in the axial direction. In order to trap both the positively charged ions and the negatively charged electrons in the same region, we plan to employ a "nested potential" configuration. This involves trapping the electrons within a local potential minimum that is located inside the larger ion trapping potential of the ions. Recent work has involved optimizing the trapping of the electron coolant by injecting electrons from a thermionic source located directly on the beam axis.

An elegant feature of cooling with electrons (rather than ions) is that they will self-cool in CPET's 7 Tesla magnetic field via the emission of synchrotron radiation. In principle, one bunch of trapped electrons can be used to cool many consecutive bunches of ions.

PLASMA OBSERVATION IN CPET

Initial attempts to trap electrons in CPET proved difficult. We discovered that this was due to the fact that the dense electron cloud was exhibiting behaviour characteristic of a non-neutral plasma. We observed that the entire column of electrons in the trap rotated about the trap axis as a result of an $\vec{E} \times \vec{B}$ drift as the plasma interacted with its own image charge on the trap wall. This so-called "diocotron" motion stymied our detection of the electron plasma for some time. Compared to ions, electrons are very light, and consequently follow the magnetic field lines as they exit the magnet. An initially small displacement of the plasma column from the centre of the trap will expand with the diverging magnetic field lines when the electrons are ejected from the trap. By the time electrons reached our detector, they were too far off-axis to be observed.

A TALE OF TWO DETECTORS

Fortunately, we were able to overcome our challenges with electron detection in order to study the electron plasma by employing two different techniques for their detection. At first, a phosphor screen was installed inside our beam line, well within the influence of the magnetic field. This allowed us to observe the radius of the diocotron motion of the extracted electrons before they were steered into the walls of the beam line by the magnetic field. We were able to draw the useful conclusion that the radius of the plasma motion damps over time [11], which is encouraging since we want to spatially overlap the ions with a high density of electrons.

Despite our success with the phosphor screen, any long-term detection of the presence of electrons in CPET needs to also allow ions to enter the trap, but the phosphor screen obstructed the beam line. We therefore designed and built a new detector based on an array of thin wires that TITAN uses for ion deflection, known as a Bradbury-Nielsen gate [12]. This new mesh detector is positioned

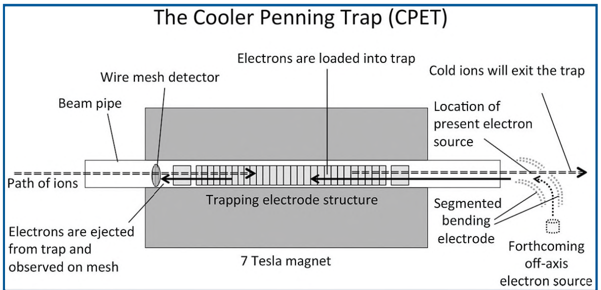

Fig. 2 Overview of CPET. Electrons (solid black line) were injected from the right, trapped for up to 1 minute, and then ejected onto the wire mesh detector. The dotted/dashed lines represent features that have not yet been implemented. A segmented bending electrode (light grey dots) will inject electrons (black dots) from off of the beam axis. This will allow for ions (dashed double line) which are injected from the left and trapped, to be ejected out the right side of the trap.

inside the magnetic field at nearly the same location as where the phosphor screen was located (see Fig. 2). When it is biased to the local drift tube voltage, ions will pass through the mesh essentially unobstructed. However, by grounding the mesh and making it a local potential minimum for the electrons, we can quantify the electron plasma in the trap by measuring the charge of the electron bunch as it hits the mesh. What was lost in not knowing the position of the electron cloud was more than made up for by the fact that we could determine their quantity. By comparing the current on the mesh when the trap is loaded with electrons and undergoes an ejection cycle to the current on the mesh when the empty trap undergoes an ejection cycle, we were able to separate the electron signal from the noise of switching electrodes.

We detected $\sim 10^8$ electrons per bunch for up to 1 minute of time stored in CPET [13]. This quantity of electrons should prove sufficient for cooling the highly charged ions, providing the electrons and ions suitably overlap.

MOVING FORWARD

We are installing a newly designed set of segmented bending electrodes to both inject the electrons from off-axis and provide steering through the magnetic field. When the bending is turned off, ions can continue through the bending electrode to our measurement trap. Having this installed will allow us to better recreate the conditions which CPET will operate under when used to cool ions in TITAN. As a result, we will be able to work towards the cooling of singly charged ions independent from the TITAN facility in order to demonstrate CPET's readiness without interfering with our science program.

The ability to cool singly charged ions will allow us to confidently incorporate CPET into the TITAN beamline so we can work to reduce the energy spread of short-lived highly charged ions in a short time frame. Once fully operational, the time of the cooling cycle will need to be optimized for the lifetime of the species of interest. Realizing electron cooling of highly charged, exotic isotopes will represent a valuable step forward in the Penning trap mass spectrometry of these extreme species.

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Relaxation of a Simulated Lipid Bilayer Vesicle Compressed by an AFM

by Ben M. Barlow, Martine Bertrand, and Béla Joós

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In water, phospholipids self-assemble to form closed membranes called *lipid bilayer vesicles* (Fig. 1). The lipids do this because they are amphiphiles: their tails are hydrophobic, but their heads are hydrophilic. The closed (vesicle) configuration, shown to the right in Fig. 1, is stable because it shields the (hydrophobic) tails from the surrounding water. At its foundation, the cell membrane is a lipid bilayer. In the context of the origin of life, that such closed membranes assemble spontaneously in nature is a very interesting fact.

Cells are very complicated mechanical objects—eukaryotic cells especially so—and vesicles have been attractive model systems for theoretical work, simulations and experiments.

SIMULATION SETUP

To investigate the viscoelastic properties of vesicles, we ran computer simulations wherein a vesicle is squeezed between two plates (Fig. 2).

This procedure is relevant to experiments [3,6] which use an Atomic Force Microscope (AFM) to poke and squeeze and stretch living cells and vesicles. Our focus is on the *dynamics* of stress relaxation in the membrane, rather than static properties.

We use coarse-grained molecular dynamics [1] in order to reproduce the basic characteristics common to all real bilayer membranes: thermal undulations, in-plane fluidity, intermonolayer friction, area compressibility and bending rigidity. The model (Fig. 2) consists of approximately 140,000 particles. Our vesicle is the same as was used in [2], its membrane composed of coarse-grained lipids having one hydrophilic 'head' particle and two hydrophobic 'tail' particles (see inset in Fig. 2). At 3000 lipids, the membrane area is large enough to achieve the macroscopic properties described by continuum models. Fig. 2 omits the outer fluid particles that surround our small unilamellar vesicle. On the scale of our simulations, we treat a rounded AFM tip as approximately flat. For giant vesicles, this corresponds to a tipless AFM cantilever. The vesicle is compressed via a step force applied uniformly to each bead in the upper crystal (AFM), whose motion is constrained to the direction normal to the substrate.

Summary

The relaxation time of bilayer vesicles, uniaxially compressed by an Atomic Force Microscope (AFM) cantilever, exhibits a strong force dependence.

DYNAMICS

Time evolution of the (triangulated) area strain α after we activate the squeezing force is described as an exponential saturation

$$\alpha(t) = \alpha_{\infty}\left(1 - e^{-t/\tau}\right) \tag{1}$$

(see Fig. 3). This viscoelastic creep response corresponds to the 'Kelvin-Voigt' model, or the more general

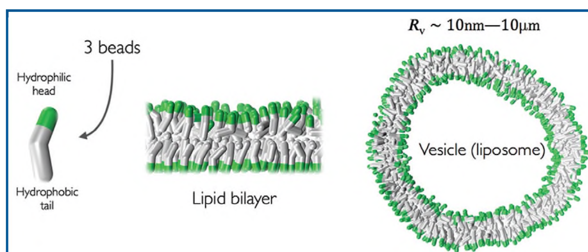

Fig. 1 Self-assembly of amphiphiles into closed quasi-spherical vesicles. In nature the closed configuration is entropically favourable because it minimizes the hydrophobic tails' exposure to the surrounding fluid. In our simulations the hydrophobic interaction is modelled by making exposure of the tails energetically costly. Thus in contrast to real vesicles, the simulated vesicle is stable because it is energetically favourable. A major benefit of the molecular dynamics approach to simulating bilayers (shown here) is that this method reproduces key properties of real bilayers —e.g. thermal undulations, in-plane fluidity, area compressibility, bending rigidity, ability to open and close pores, etc.

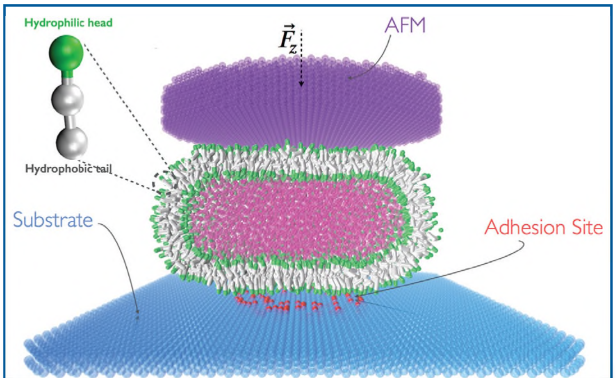

Fig. 2 Simulated vesicle undergoing parallel plate compression. In addition to the ordinary substrate particles, a bullseye of randomly distributed 'sticky' particles was placed at the centre of the substrate to ensure adhesion. Without this *adhesion site*, the vesicle would slip out from underneath the AFM. Coarse-grained lipid shown at upper left. (An analogous experimental setup was used by Schäfer et al.[6] to investigate *static* properties of giant liposomes.)

'Standard Linear Solid' model. In this model the relaxation time is $\tau \sim \eta/K$, where η is a viscosity and K is an elastic modulus.

RELAXATION TIME VERSUS TENSION

As it turns out, the relaxation time τ depends on the magnitude of the applied stress. In Fig. 4, we plot $\tau(\gamma)$—relaxation time versus surface tension. (The tension, estimated via the α-contribution to the work done compressing the vesicle, scales nearly linearly with the squeezing force.) The sharp rise in the vesicle's relaxation time at low force arises from the effect of entropic undulations on the area expansion.

We have fit the $\tau(\gamma)$ data using Equation 6, which we will now derive.

Thermal agitation excites undulations in the vesicle membrane. Due to these undulations, the surface area of a vesicle as measured in the lab will be less than the true surface area of its membrane. Hence a distinction is made between 'apparent' or 'projected' versus true surface area of the membrane. In 1984, Helfrich and Servuss (HS) [4] derived an expression connecting the relative change in a membrane's apparent area ΔA to its surface tension γ:

$$\alpha(\gamma) \equiv \left(\frac{\Delta A}{A}\right)_{\gamma>0} = \underbrace{\frac{k_B T}{8\pi\kappa}\ln\left(\frac{\frac{\zeta\kappa}{A}+\gamma}{\frac{\zeta\kappa}{a}+\gamma}\right)}_{entropic} + \underbrace{\frac{\gamma}{K_A}}_{direct}, \tag{2}$$

where K_A, κ, A and a are the membrane's area compressibility modulus, bending rigidity, unstressed area and area per lipid, respectively. k_B is Boltzmann's constant, T is the temperature,

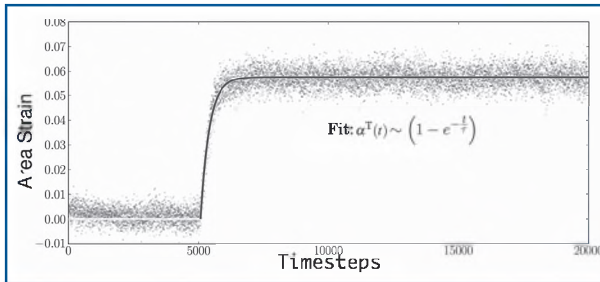

Fig. 3 Ensemble fit to creep response of the bilayer's triangulated area. For each value of the applied force, data from multiple simulations are fit as one time-series. This helps to reduce the uncertainty on the relaxation time, by reducing the influence of noise from any particular simulation on the fit.

and ζ depends on membrane shape. (E.g. $\zeta = \pi^2$ for a planar membrane, and for a sphere $\zeta = 24\pi$.) For small $\Delta(\cdot)$ we know that

$$\Delta(strain) = \frac{1}{K}\Delta(stress) \approx \left(\frac{\partial(strain)}{\partial(stress)}\right)\Delta(stress). \tag{3}$$

For a stretching membrane $strain = \alpha$ and $stress = \gamma$, so that

$$\frac{1}{K} \equiv \frac{\partial(strain)}{\partial(stress)} = \frac{\partial\alpha}{\partial\gamma} \tag{4}$$

defines the stiffness of the *apparent* surface.

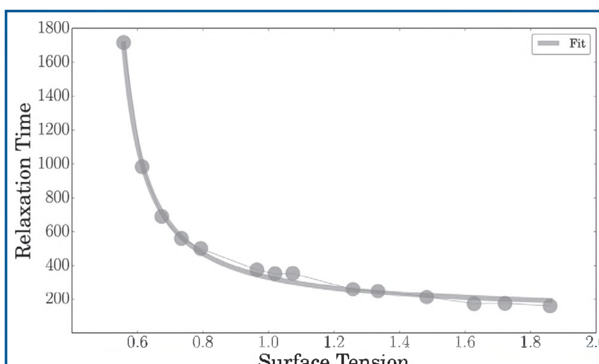

Fig. 4 Relaxation time versus surface tension, fit to Equation 6. Derived out of the HS model, $\tau(\gamma)$ (Equation 5) leads to a correct description of the force dependence of the relaxation time. (The tension scales nearly linearly with the squeezing force. Figure axes are in dimensionless units.)

From the HS model and linear viscoelasticity theory, we derive the relaxation time

$$\tau(\gamma) \sim \eta\left(\frac{1}{K}\right) \approx \eta\left(\frac{\partial\alpha}{\partial\gamma}\right) \approx \eta\left(\frac{1}{K_A} + \frac{\frac{k_B T}{8\pi\kappa}}{\frac{\zeta\kappa}{A} + \gamma}\right). \tag{5}$$

A phenomenological form consistent with both the low and high tension limits of 5 is

$$\tau \approx C_1 + \frac{C_2}{C_3 + \gamma}, \tag{6}$$

where C_1 is the high-tension asymptotic limit and $C_1 + \frac{C_2}{C_3}$ is the finite limit as $\gamma \to 0$. Going a step further, in Fig. 4 we have fit the entire $\tau(\gamma)$ curve with this function, which succeeds as a phenomenological model. Though the fit extends beyond small $\Delta\gamma$, it yields a reasonable estimate of η/K_A.

CONCLUSION

The relaxation time depends on the magnitude of the applied stress, increasing sharply in the limit of low stress. This is caused by entropic undulations in the bilayer. Equation 5 predicts a *finite maximum relaxation time, proportional to the membrane's surface area*, so the effect should be *stronger* in cell-sized systems. Moreover, since undulations have been observed in real vesicles and cells, the force-dependence should be present in them as well. The connection between our vesicle's relaxation time, entropic undulations and the applied stress may help to explain the wide variability of relaxation (and recovery) times reported for cells [3,5].

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A FORMATION PROCESS AND GROWTH MODEL FOR SUPERHEATED LIQUID BUBBLE CHAMBERS

BY ALEXANDRE LE BLANC, UBI WICHOSKI, AND IAN LAWSON

Dark matter is believed to be made of an unknown kind of particle. Its detection has been a challenge for more than 3 decades [1]. PICO is a direct dark matter search experiment that uses superheated liquid bubble chambers with different fluorocarbons as target liquids. The acoustic signal generated by the explosive phase transition caused by particles interacting with the target liquid is used for data analysis. A better understanding of the mechanisms that generate the acoustic signal provides better tools to discriminate amongst the particles that can create bubbles. Models of bubble formation and growth are a starting point to understand the mechanisms of the acoustic signal generation.

THE BUBBLE FORMATION MODEL

A model originally proposed by F. Seitz in 1956 is used to explain the bubble formation process [2]. The model quantifies the minimum amount of energy which needs to be deposited and the region in which this energy has to be deposited to form a bubble. The model also gives a prediction of the detector's response to different background particles which include neutrons and alphas. The vapour bubble equilibrium conditions are used by the model to quantify the above mentioned parameters. At equilibrium, the temperature inside and outside must be equal and using the assumption that the vapour has a constant isothermal compressibility, the pressure inside the bubble and the radius of the bubble are related by the following equations [3],

$$2\sigma = (p' - p'')r \tag{1}$$

$$p' = p_{sat} e^{\frac{-\rho'_{sat}}{\rho''}\left(\frac{p_{sat}-p''}{p_{sat}}\right)} \tag{2}$$

$$r = \frac{2\sigma}{(p_{sat} - p'')\left(1 - \frac{\rho'_{sat}}{\rho''}\right)} \tag{3}$$

where p is the pressure, r is the radius, ρ is the density, σ is the surface tension, $'$ represents inside the bubble and $''$ represents outside the bubble and the subscript *sat* denotes the property at saturation. The amount of heat that needs to be supplied to form a vapour bubble is the sum of the energy to vapourise the liquid, the work to create the volume and the energy to create the surface. This is represented by the following equation [3],

$$Q = 4\pi r^2\left(\frac{\sigma}{3} - T\frac{\partial\sigma}{\partial T} + \frac{m_s}{\rho' - \rho''}\rho'(h'_m - h''_m)\right) + \frac{4}{3}\pi r^3\rho'(h'_m - h''_m) \tag{4}$$

where T is the temperature, h_m is the enthalpy per unit mass and m_s is the mass per unit area. Having calculated the minimum energy necessary to form a bubble, simulations of particle tracks inside the detector can be performed to predict which particle interactions will produce a bubble. A Monte Carlo simulation program called TRIM [4] can simulate particle tracks and their interactions in different materials. As an example of a TRIM simulation, alpha and neutron tracks are analysed in C_3F_8 as the target liquid. An alpha particle will deposit its energy slowly at the beginning of the track and much more quickly at the end, i.e. the Bragg peak. For the neutron, however, the mean free path of interaction is very long compared to that of the alpha particle, and therefore the mechanism to create a bubble is different. The first interaction of the neutron will be with either a fluorine or a carbon and that atom will create the cascade that deposits the energy to form the bubble. The bubble volume with equilibrium radius, r, corresponds to a volume of liquid to be evaporated, $R = r(\rho'/\rho'')^{\frac{1}{3}}$. Once the particle tracks are generated, the volume R is scanned along the track where the sum of all energies is calculated; if this sum is greater than the minimum energy found in Eq. 4, a bubble is postulated to be formed. In a controlled environment where the flux and energy of particles are known, a prediction of bubble rates can be made. A graphic example of an alpha track and a neutron track from a fluorine cascade is shown in Fig. 1.

A problem with this method is that the track is considered static in time. However, the energy from interactions dissipates through phonons and therefore the scan should

SUMMARY

This paper presents a summary of an M.Sc. project on bubble formation and growth models in superheated liquid bubble chambers.

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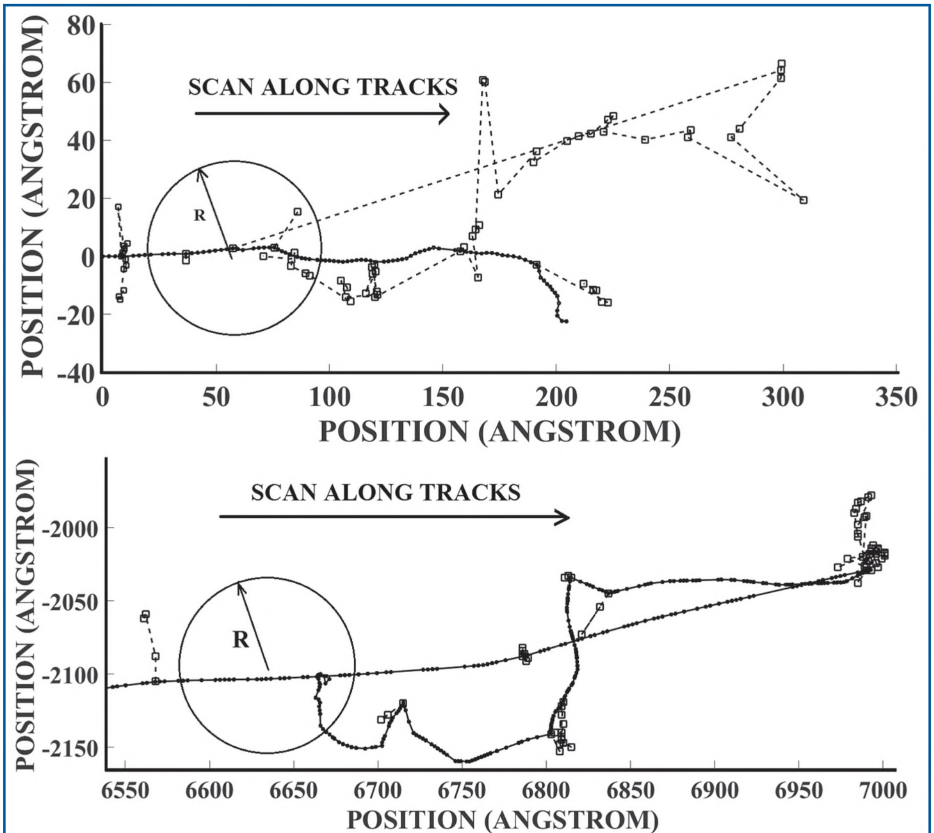

Fig. 1 Example particle tracks of an alpha and a fluorine cascade from a neutron, top plot, and an alpha, bottom plot. The solid lines are the particles and the square dashed lines are cascades. Note that for the alpha track there is a cascade cluster on the right hand side.

be performed in real time where phonon dissipation is allowed to occur. If an interaction occurred close to the edges of the time window, inside or outside, energy can flow in or out.

THE BUBBLE GROWTH MODEL

Equipped with the information about vapour bubbles, the bubble growth can now be investigated. As will be seen, bubble growth can be used as a tool to discriminate amongst particles that induced the bubble formation. Bubble growth is a two phase flow problem. For PICO's purposes, the vapour bubble interface position, velocity and acceleration need to be known. Two equations summarize the problem [5],

$$R\frac{d^2R}{dt^2}+\frac{3}{2}\left(\frac{dR}{dt}\right)^2=\frac{P'-P''}{\rho''}-\frac{2\sigma}{\rho''R}-\frac{4\mu}{\rho''R}\frac{dR}{dt} \quad (5)$$

$$\frac{\partial T}{\partial t}+\frac{R^2}{r^2}\frac{dR}{dt}\nabla_s T=\alpha\nabla_s^2 T \quad (6)$$

where R is the interface position, μ is the dynamic viscosity, α is a thermal diffusion constant and r is the position. These equations can be solved with the correct numerical model, grid space and boundary conditions. The expected solution should be of the form shown in Fig. 2 [4].

This particular solution was calculated for superheated water. The simulation starts at the equilibrium radius with a temperature disturbance of varying magnitude. The interface position as a function of time is shown in the bottom curves of Fig. 2. These curves show two important parts of the bubble growth, a degenerate growth at the end, and a non-degenerate growth near the beginning. The non-degenerate part can be made clearer with the interface velocity shown in the top curves in Fig. 2. The magnitude of the initial temperature disturbance gives rise to substantially different bubble growth. That's the key to particle discrimination. Suppose that an alpha deposits most of its energy very quickly in the Bragg peak which is localised, whilst the neutron deposits its energy through a cascade which is slower and less localised, shouldn't this translate to different initial temperature disturbances for bubble growth? If so, this is why bubble growth can be used as a tool for particle discrimination. However, there is one more important part of bubble growth, the interface acceleration as shown in the top curves of Fig. 3 [4].

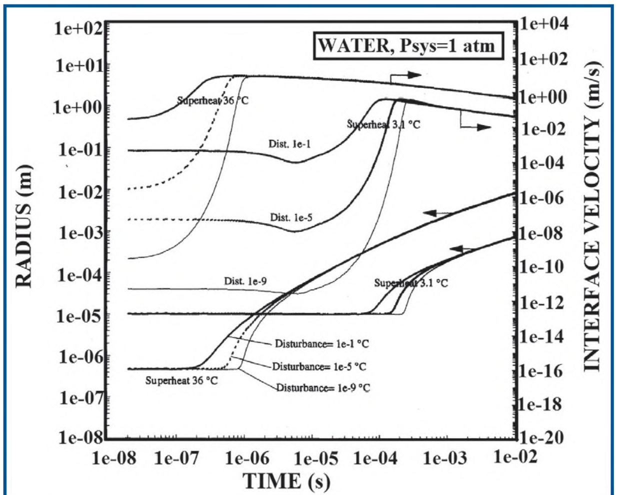

Fig. 2 Expected solution to the coupled differential equations (5) and (6) for different initial temperature disturbances. This solution is for superheated water at 1 atmosphere and shows the interface velocity, $\frac{dR}{dt}$ (top plots), and the interface position, R (bottom plots). Arrows point to the correct axis.

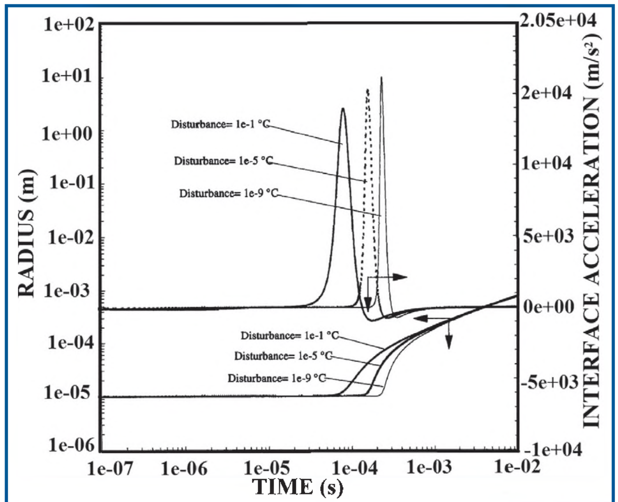

Fig. 3 Expected solution for the interface acceleration, $\frac{d^2R}{dt^2}$, of the coupled differential equations (5) and (6) for different initial temperature disturbances. Arrows point to the correct axis.

The interface acceleration is responsible for the acoustic shock, which is responsible for the acoustic signal. Therefore, by working backwards from the registered acoustic signal to the acoustic shock and to the disturbance, a prediction of which type of particle that caused the bubble can be made.

CONCLUSION

The bubble formation model can be improved to better understand the detector response and to be able to translate the deposited energy into an initial disturbance for the bubble growth model. The bubble growth model has to be completed for C_3F_8 and confirm the effects obtained for water [5].

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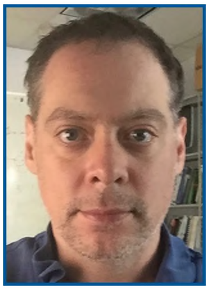
THEORY CANADA 11 CONFERENCE: YET ANOTHER SUCCESS

BY THOMAS GRÉGOIRE AND SVETLANA BARKANOVA



The Theory CANADA conference, launched in 2005 as a satellite conference for the annual Canadian Association of Physicists (CAP) congress, celebrated its 10th-year anniversary in 2015 [1] and was yet another success in 2016. This unique conference brings together theorists from all regions of Canada, aiming to foster collaboration and exchange of ideas across disciplines. One of the goals of Theory CANADA is to give an opportunity to physicists from across various subfields to learn from each other so all the sessions of the conference are plenary, with no parallel talks, and always plenty of time set aside for discussions and informal interactions. Another goal is to engage the new generation of Canadian physicists, like new faculty members, postdocs and graduate students. The broad themes of the conference are normally (i) Mathematical Physics, (ii) Quantum Gravity and Strings, (iii) Particles and Fields, (iv) Relativity, Gravitation and Cosmology, (vi) Condensed Matter Theory, and (v) Quantum Information.

The 11th edition of the Theory CANADA conference was held from Friday June 10 to Saturday June 11 2016 at Carleton University in Ottawa, right before the beginning of the CAP congress at the University of Ottawa. There were more than 50 participants from all over Canada, from British Columbia to Newfoundland. The participants were theoretical physicists working in various subfields, from cosmology to theoretical condensed matter physics.

After introductory remarks by Carleton's Dean of Science Malcom Butler, also a theorist, the DTP/WITP thesis prize was presented to Vincent Genest (Ph.D., Université de Montréal) for his thesis entitled "Algebraic Structures, Super-Integrable Systems and Orthogonal Polynomials". The prize has been jointly awarded by the Division of Theoretical Physics (DTP) and the Winnipeg Institute for Theoretical Physics (WITP) to a student receiving a Ph.D. degree in Physics from a Canadian University with a thesis in Theoretical Physics. Vincent, who is now at MIT, was

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Participants of Theory CANADA 11 at Carleton University.

also an invited speaker for Theory CANADA 11 giving the opening talk of the conference in the "Mathematical Physics and Quantum Computing" session. The other sessions of the Friday were "String Theory" and "Condensed Matter".

At the end of the talks on Friday the participants were invited to a reception which was then followed by a public lecture on gravitational waves. The lecture was given by Harald Pfeiffer from the University of Toronto and CITA. It was a big success with over 200 attendees and a long question period at the end. Following the lecture, everybody was invited to observe the moon with Etienne Rollin, a lab supervisor in the department, who had brought his telescope for the occasion. On Saturday we had the "Particle Physics" and "Cosmology, Astrophysics and Gravitation" sessions. Finally, the conference ended with a banquet at the East India Company restaurant in downtown Ottawa.

The conference was a big success with 32 talks, 8 of which were by invited speakers. Details from the conferences and most of the presentations can be found at http://physics.carleton.ca/theory-canada-11 and https://indico.physics.carleton.ca/event/0/.

The organizing committee consisted of Thomas Grégoire (Carleton U., Chair of the Organizing Committee), Steve Godfrey (Carleton U.), Heather Logan (Carleton U.), Daniel Stolarski (Carleton U.), Svetlana Barkanova (Acadia, DTP Chair), and Ariel Edery (Bishop, DTP Vice-Chair).

We would like to thank the Centre de Recherches Mathématiques (CRM), the Fields Institute, the Canadian Institute for Theoretical Astrophysics (CITA), the Perimeter Institute, the Faculty of Science and the Physics Department at Carleton University for their financial support.

Theory CANADA 12 will be hosted by York University (Toronto, Ontario), May 25-27, 2017, right before the CAP Congress hosted by Queen's University (Kingston, Ontario), May 29 – June 2, 2017. As it is customary for Theory CANADA conferences, we will sponsor accommodation of invited speakers, graduate students and postdoctoral fellows, and, funding permitting, accommodation to all participants. There are no registration fees for the CAP Congress delegates, and we will organize transportation from TC to CAP (Toronto to Kingston). Please contact the TC12 conference chair, Matthew Johnson, Physics & Astronomy at York University, matthewj@yorku.ca for details.

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CAP-TRIUMF Vogt Medal for Contributions to Subatomic Physics

La Médaille Vogt de l'ACP-TRIUMF pour l'excellence en physique subatomique

At every stage of his career, Konaka's research has impacted rare-process physics. His doctoral work developed techniques to search for weakly interacting particles, like axions, that have since found new life in "dark photon" searches. As a TRIUMF researcher working at Brookhaven National Laboratory in the 1990s, he introduced a blind analysis technique to increase confidence in Experiment 787's ultra-rare kaon-decay result that has since become the standard in the field. As the Canadian leader for the T2K experiment, he successfully pushed for the use of an off-axis neutrino beam, and led the development of key detector and analysis systems, innovations that had a major impact on T2K's dramatic result establishing electron neutrino appearance from a muon neutrino beam, a result that led to the 2016 Breakthrough Prize in Fundamental Physics. His innovations continue with a new proposal to reduce neutrino flux and cross section uncertainties at an upgraded T2K-Phase 2, which could lead to a significant measurement of the CP violation parameter delta, the holy grail of neutrino-oscillation physics.

His experimental contributions have been matched by his energetic leadership in Canadian physics, where he established and led T2K-Canada through the crucial development phases, and built a Canadian collaboration for the new ultra-cold neutron (UCN) facility at TRIUMF. He remains a powerful advocate for Canada in Japan. All told, Konaka embodies what the Vogt Medal is all about.

The 2016 CAP-TRIUMF Vogt Medal for Contributions to Subatomic Physics is awarded to Dr. Akira Konaka, TRIUMF, for his outstanding contributions to the T2K long-baseline neutrino experiment, including his leadership in establishing the collaboration. His innovations to the experiment's design and analysis methods were critical in the discovery of electron neutrino appearance from the muon neutrino beam, a discovery that led to the T2K project being recognized by the 2016 Breakthrough Prize for Fundamental Physics. The committee also recognized ongoing innovations with new concepts proposed to improve the precision of the T2K experiment and, potentially, the Hyper-K experiment.

La Médaille Vogt de l'ACP-TRIUMF pour l'excellence dans le domaine de la recherche théorique ou expérimentale en physique subatomique 2016 est décernée au Dr Akira Konaka, TRIUMF, pour son leadership dans la mise sur pied de l'expérience T2K et ses apports novateurs à la fois à concevoir l'expérience et à analyser les méthodes. Ces apports ont tous deux été essentiels à la découverte d'une apparence de neutrinos électroniques dans le faisceau de neutrinos muoniques, découverte qui a mené à la reconnaissance du projet T2K à l'égard du Prix pour percée de la recherche en physique fondamentale. Le comité a aussi reconnu que ces innovations reprennent de nouveaux concepts proposés afin d'améliorer la précision de l'expérience T2K et, peut-être, de l'expérience Hyper-K.

Recipient of the 2016 Medal / Lauréat de la médaille 2016:

Dr. Akira Konaka

Remarks by Akira Konaka

I am honoured to receive the CAP-TRIUMF Vogt medal. It is in particular special with a heartfelt memory of Dr. Vogt in his cheerful loud voice of "Kon-nichi-wa" (hello in Japanese) since I moved to TRIUMF in 1988. He represented the welcoming environment in Canada where I have been involved in rare kaon decay and then neutrino oscillation projects.

The mysterious three generation structure of quarks and leptons has attracted me since I was a graduate student. Mixing between different generations is explained by mass and weak interaction allowing us to see the generation structure differently, even though it is the same "particle". As a result, muon neutrino produced by a weak decay of pions travels as a quantum superposition of three generations of masses. The interference of these mass eigenstates create different weak eigenstate component to appear after traveling a long distance. In the T2K long baseline neutrino oscillation experiment, we observed such explicit appearance of one type of neutrino (electron neutrino) emerging from another type (muon neutrino) after travelling 295km from the east coast to the west coast of Japan for the first time.

"I am honoured to share this award with my amazing T2K colleagues in Canada in developing the ground work towards discovering CP violation in neutrino oscillations. This award is particularly important and reminds me of Dr. Erich Vogt's cheerful encouragements of my research."

« Je suis honoré de partager ce prix avec mes étonnants collègues du projet T2K au Canada dans la réalisation du travail préliminaire sur la violation de CP dans les oscillations de neutrinos. Ce prix est particulièrement important et me rappelle les heureux encouragements du Dr Erich Vogt à l'égard de mes recherches. »

Historically, this mixing effect was first discovered in quarks although they instantly turn into mass eigenstate after production by the weak interaction. The concept of this quark mixing lead to the prediction of charmed quarks to explain the absence of flavour changing neutral current, and the third generation top and bottom quarks to explain the observed CP violation in kaon decays. Very precise studies of quark mixing using B and K decays, which I also took part through rare kaon decays, show the quark mixing to work extremely well.

In 1998, neutrino oscillation in atmospheric neutrinos was discovered by Super-Kamiokande (SK). It observed a surprisingly large deficit in the muon neutrinos coming from the bottom of the earth compared to the down going neutrinos from the top of the sky, which can be explained by muon neutrino to tau neutrino oscillation while traveling a long distance through the earth. This discovery was followed by the observation of deficit in the electron neutrinos coming from the sun compared to the total number of neutrinos measured by neutral current interaction simultaneously by SNO experiment. Nobel prize was awarded last year to Prof. Takaaki Kajita (SK) and Prof. Arthur McDonald (SNO) for the discovery of neutrino oscillation.

Like many particle physicists, the discovery of neutrino oscillation had deep impact and changed my research from quarks (kaons) to neutrinos (leptons). I took sabbatical leave to Japan in 2000 to develop a new long baseline neutrino project, which is now called T2K. The oscillation between muon and electron neutrinos (electron neutrino appearance) was, and still is, the key for the next step to measure the remaining mixing angle θ_{13} and the CP violation phase d. However, the general perception was that a special facility with muon storage ring (neutrino factory) would be needed. We studied the possibility of electron neutrino appearance using a conventional horn focused neutrino beam from the J-PARC accelerator facility to the existing SK detector, the world largest neutrino detector. It turned out that the 295km travel (baseline) length between J-PARC and SK sets the neutrino oscillation maximum at around 600-800MeV where SK has excellent performance and the neutrino energy reconstruction is possible since the cross section is dominated by 2-body quasi-elastic interaction. We further introduced an idea of aiming the beam slightly off the SK direction (off-axis beam), which was accidentally found by a summer student at TRIUMF, to enhance the beam at oscillation maximum and at the same time reduce the background from higher energy tail.

The Canadian subatomic physics community has a tradition to focusing on key scientific projects as a community, and the T2K project attracted excellent experienced Canadian scientists. It also attracted young "rising star" scientists, Prof. Scott Oser and Prof. Hiro Tanaka, to join the project. The big turning point for both the international and Canadian T2K projects was a workshop held at the Dunsmuir lodge of University of Victoria in November 2001 where world prominent physicists gathered, including SNO physicists, future T2K physicists, Fermilab/CERN neutrino physicists, as well as the spokesperson of SK (Prof. Yoji Totsuka) and T2K (Prof. Koichiro Nishikawa) to discuss the future direction in neutrino physics. As a result, a long baseline neutrino oscillation group was formed. A side note is that Prof. Totsuka learned the terrible news on his way back of the workshop that an implosion accident destroyed more than half of the 11,000 photomultipliers in SK. With a strong determination and dedication, the SK detector resumed its operation in one year.

The Canadian group made key intellectual contributions to the T2K project; the off-axis beam concept, dual accelerator kicker concept, primary proton beamline optics, target remote handling system, optical transition radiation (OTR) beam monitor in front of the target, the near tracking detector consisting of fine grained scintillator detector (FGD) and time projection chamber (TPC), and event reconstruction of the SK detector. At TRIUMF, we also host the collaboration web page, data base, and one of the two Tier-1 data storage centres for the T2K project. The T2K project would not be possible without the amazingly talented and productive Canadian physicists and engineers.

The physics data taking started in 2010. In 2011 we observed six electron neutrino appearance candidates with a significance of 2.5σ. This was a big surprise as it indicates the θ_{13} mixing angle to be large. The experiment was unfortunately halted in March 11, 2011 when a big earthquake hit Japan, seriously damaging accelerator components. In the mean time, reactor neutrino experiments confirmed the large θ_{13} using disappearance method in early 2012 at 5σ level. T2K resumed data taking one year later has 28 electron neutrino appearance events with 7σ significance and currently is accumulating anti-electron neutrino appearance data to study CP violation, the difference between neutrino and anti-neutrino oscillations, which have started to show some hints and constrain the CP violation parameter space.

The T2K collaboration proposes to continue accumulating data for the next 10 years with tripled beam intensity (T2K-II) to observe the CP violation, which would provide us a hint to understanding the matter-antimatter asymmetry of the universe (Leptogenesis). The precision studies of neutrino mixings might also provide information of the origin of the very tiny neutrino mass and the generation structure, which is expected to come from the very high energy scale that accelerators cannot access (see-saw mechanism). In order to achieve this goal, it is essential to control the systematic uncertainties, in particular those coming from neutrino-nucleus interactions. The Canadian group is proposing an innovative intermediate near detector, NuPRISM. It covers ranges of off-axis angles to determine the neutrino cross sections in a model independent way. Beyond T2K, we propose an order of magnitude larger detector, Hyper-Kamiokande (HK) to start operation in 2026 after T2K-II. The HK detector will serve as an accelerator neutrino detector as well as a neutrino astrophysics observatory for supernova, solar, and atmospheric neutrinos, and as a sensitive detector to search for proton decays and dark matters. There are exciting physics discovery opportunities in the decades to come.

In closing, I would like to express my deep gratitude to my colleagues of the T2K collaboration, in particular the amazing Canadian T2K collaborators and technical staffs, for providing such an exciting experience. Canada has become one of the most preferred destination for eager neutrino physicists. I would also like to thank TRIUMF, the Canadian subatomic physics community, CAP, NSERC, and CFI for their support.

CAP-CRM Prize in Theoretical and Mathematical Physics

Le Prix ACP-CRM de physique théorique et mathématique

Dr. Freddy Cachazo is a theoretical physicist who has made outstanding contributions to the field of mathematical physics, many of which are widely characterized as breakthroughs. With collaborators, Cachazo has creatively drawn upon a variety of elegant mathematical ideas to develop entirely new methods for studying scattering processes in gauge theories and gravity. Cachazo's contributions to quantum field theory range from applications of geometric engineering (in string theory) to understanding mysterious dualities relating theories in different dimensions to novel techniques to compute scattering amplitudes in Quantum Chromodynamics (and its generalizations). The latter has brought relatively new mathematics into physics, such as the positive Grassmannian and its combinatorial structure, the positroid.

Recipient of the 2016 Prize / Lauréat du prix 2016:

Dr. Freddy Cachazo

Beyond providing deep new insights into the structure of quantum field theory, these new methods have had a major impact on high-energy physics, as evidenced by the fact that the Britto-Cachazo-Feng-Witten (BCFW) technique has already been incorporated into the newest edition of the celebrated textbook, Quantum Field Theory in a Nutshell, by Anthony Zee (2010) and in the new textbook, Quantum Field Theory and the Standard Model, by Matthew D. Schwartz (2015).

The physical and mathematical principles underlying Cachazo's research are profound. Cachazo's 60 papers since 2001 have attracted over 7,500 citations, attesting to the enormous influence of his new insights. Besides being of utility to huge accelerator experiments, Cachazo's works will have enduring and far-reaching impact in the search for a simpler, unified description of nature's physical laws and its connection to mathematics.

The 2016 CAP-CRM Prize in Theoretical and Mathematical Physics is awarded to Dr. Freddy Cachazo, Perimeter Institute, for introducing elegant new mathematical ideas and methods that have led to unexpected insights in the way scattering amplitudes are calculated in Supersymmetric Yang-Mills theory. Inspired in part by twistor-string theory, the Cachazo-Svrcek-Witten (CSW) and Britto-Cachazo-Feng-Witten (BCFW) recursion relations revolutionized the field, making it possible to perform previously impossible calculations analytically in a few lines using explicit integral formulae. These results turned out to be in remarkable correspondence with structures explored concurrently by mathematicians for completely different purposes, establishing a suggestive link with the modern theory of integrable systems.

Le Prix ACP-CRM de physique théorique et mathématique 2016 a été décerné au D^r^ Freddy Cachazo, Institut Périmètre, pour avoir introduit d'élégantes nouvelles idées et méthodes mathématiques conduisant à des percées insoupçonnées dans le calcul d'amplitudes de diffusion en théorie de Yang-Mills supersymétrique. Les relations de récursivité de Cachazo-Sverczek-Witten (CSW) et de Britto-Cachazo-Feng-Witten (BCFW), inspirées en partie de la théorie des cordes et twisteurs, ont révolutionné le domaine, rendant possibles en quelques lignes, grâce à des formules intégrales explicites, des calculs analytiques auparavant impossibles. Ces résultats se sont avérés correspondre de façon remarquable à des structures examinées en même temps par des mathématiciens à des fins tout à fait différentes, établissant un lien suggestif avec la théorie moderne des systèmes intégrables.

REMARKS BY FREDDY CACHAZO

I am very honoured to be recognized by my colleagues in the Canadian Association of Physicists and the Centre de recherches mathématiques. Physics and mathematics are disciplines where cross-fertilization often happens; I have been very fortunate to have seen this process in action, and would like to thank my collaborators, who are both physicists and mathematicians, for a very exciting journey that culminated in the publication of a book with Cambridge University Press this year.

The story started in 2004, Ruth Britto, Bo Feng and I were postdoctoral fellows at the Institute for Advanced Study (IAS) in Princeton. Ruth and Bo joined my research, trying to use complex analysis techniques to compute scattering amplitudes of gluons in novel ways.

The textbook technique for these computations is known as Feynman diagrams. The diagrams tell a story of physical particles interacting through the exchange of virtual ones, i.e., off the mass shell.

Our technique naturally led us to different space-times, where internal lines can be promoted to physical particles, i.e. can be made to lie on the mass shell. Early in 2005, we developed a simple, general and elegant construction in collaboration with Edward Witten (Professor at the IAS), which is now known as the BCFW technique.

The BCFW technique replaces Feynman diagrams by on-shell diagrams. These are graphs with vertices decorated by two possible colours (bicoloured graphs). In 2008, I was lucky to have Nima Arkani-Hamed, a professor at the IAS, join our exploration with several of his talented students. We established a very fruitful collaboration, and in 2009, we found that these on-shell diagrams could be computed using contour integrals on a Grassmannian manifold.

This was a completely unexpected development, as Grassmannians are not encountered very often in physics. This led us to conjecture the existence of a duality for the scattering matrix of a supersymmetric theory of gluons. In 2010, Simon Caron-Huot, a brilliant young postdoctoral fellow at the IAS, joined our collaboration and together, we achieved an all-loop formulation (for all orders in the perturbation theory) in the limit where only planar graphs contribute.

"I would like to thank the Canadian Association of Physicists and the Centre de recherches mathématiques for this remarkable honour. I would also like to thank my collaborators, both physicists and mathematicians, for years of exciting research adventures."

In 2006 –following a completely independently line of research – Alexander Postnikov, a mathematician at MIT, studied a special class of graphs called plabic graphs (short for planar bicoloured graphs). As it turns out, Postnikov had found a natural connection between plabic graphs and cells in what is known as the positive part of Grassmannians!

In 2010, we stumbled upon Postnikov's work and arranged a meeting at MIT. It became clear that our on-shell diagrams were naturally connected to his plabic graphs. A burst of new ideas emerged, among them, a clear connection with cluster algebras, which we had been exploring with Alexander Goncharov, a mathematician who was then at Brown University.

« J'aimerais remercier l'Association canadienne des physiciens et physiciennes et le Centre de recherches mathématiques de l'honneur insigne qu'ils me font. Je tiens aussi à remercier mes collaborateurs, physiciens et mathématiciens, pour ces années d'aventures de recherche passionnantes. »

After almost two years of intense activity, a coherent picture emerged in which the known math helped shape new physics, and the known physics helped discover new math. The exciting results of our findings are now published in the book *Grassmannian Geometry of Scattering Amplitudes*. I would like to end by thanking my co-authors Nima Arkani-Hamed, Jacob Bourjaily, Alexander Goncharov, Alexander Postnikov, and Jaroslav Trnka for all their hard work, enthusiasm, and passion for physics and mathematics.

CAP-INO Medal for Outstanding Achievement in Applied Photonics

La Médaille de l'ACP-INO pour contributions exceptionnelles en photonique appliquée

A scientist with extensive experience in astrophysics and optics, Richard Boudreault has built his career applying his curiosity and creative problem-solving skills to developing and commercializing promising technologies. In his studies and early career, Richard worked with Dr. René Racine on the Ritchey-Chrétien telescope at Mt-Mégantic and Dr. Pim Fitzgerald in globular cluster astrophysics. He conceived numerous space-based optical instruments that were flown on spacecrafts by the NASA and the European Space Agency, and were instrumental in the development of the world's first time-domain laser imaging system to detect cancer. He also developed software for detecting and locating distressed pilots using Doppler shifts on emergency beacons. Richard's diversity of experience extends to the advanced materials sector, where he developed methods for producing high-purity alumina; high-purity alumina is used in products like LEDs, lasers, and photonic crystals. Richard has returned to his roots in optics in his current role as Chairman of the Board at Anyon Systems, where he advises a team of young entrepreneurs developing a topological quantum computing system. Moreover, in his role as Executive Chairman of Sigma Energy Storage, he is at the forefront of climate change challenge.

Recipient of the 2016 Medal / Lauréat de la médaille 2016:

Mr. Richard Boudreault

In addition to mentoring tech entrepreneurs, Richard has contributed to the development of future scientists by teaching at universities such as Université de Sherbrooke and Cornell University, as well as at visionary global education initiatives such as the International Space

University. He appears regularly on national television and radio, where he provides technical insight and interpretation of science news for the general public, especially relating to aerospace.

Richard has a 37-year track record as an entrepreneur, C-level general and innovation manager, and an expert practitioner of corporate governance. He has held CEO, CRO, and top corporate finance positions in both large and small companies, across private and public sectors, and has sat on or chaired on more than 30 Board of Directors of private, public, non-profit, and governmental organizations. Additionally of being a Professional Physicist, he is also Fellow of Canadian Academy of Engineers, of the Canadian Aeronautics and Space Institute, of the International Academy of Astronautics and Associate Fellow of the American Institute for Aeronautics and Astronautics.

The 2016 CAP-INO Medal for Outstanding Achievement in Applied Photonics is awarded to Richard Boudreault, Chairman Polar Knowledge Canada, for his impressive career and intellectual property portfolio, as well as direct contribution to the establishment of several companies based on photonics technologies, namely Orbite Aluminae (production of high-purity Al-oxide and rare-earth with world's first clean technology) and ART (development of two imaging systems based on the TPSF technology - molecular imaging based on time-resolved fluorescence for small animal imaging, and NIR TPSF spectroscopic system for early breast cancer detection).

La Médaille de l'ACP-INO pour contributions exceptionnelles en photonique appliquée 2016 est décernée à Richard Boudreault, Président du conseil de Savoir Polaire Canada, pour sa prestigieuse carrière et son portefeuille de propriété intellectuelle, ainsi que sa contribution directe à la création de plusieurs compagnies fondées sur les technologies photoniques, soit Orbite Aluminae (production d'oxyde d'aluminium et de terres rares à haute pureté avec la première technologie propre du monde) et ART (mise au point de deux systèmes d'imagerie fondée sur la technologie TPSF - imagerie moléculaire reposant sur la spectrofluorimétrie à résolution temporelle pour l'imagerie de petits animaux, et système de spectroscopie NIRS TPSF pour le dépistage précoce du cancer du sein).

Interview with Richard Boudreault, June 2016 (By Robert Fedosejevs)

RF Maybe we'll just start with your background. Where did you receive your training and what were the roles of the various institutions in shaping your background to get you started in physics?

RB I was quite interested in physics during high school and went through junior college, which is called CEGEP, in pure and applied science. I was aiming for a career in engineering, but I had strong interests in physics and I applied to both engineering and physics department and was accepted in physics at Sherbrooke University which was quite far from Montreal where I lived and decided two weeks before the start of the school year to apply to University of Montreal where I had not applied yet. I went to see the head of the faculty over there and said 'I want to come and start next week' and he said, 'well, let's review your grades and everything'. Then I was accepted and I started a physics degree at U de M. From the onset, I got very strongly interested in quantum mechanics and optics, but I decided after my physics degree to go work. After graduating I went off to work for a flight simulator company named CAE. Simulators are not really physics per se, but there is a lot of physics involved. I did mostly engine simulators, which involves a level of thermodynamics and fluid dynamics. To be effective, I had to re-learn thermodynamics, but from an engineer's point of view, which is a quite different affair. While I worked, I went to a graduate seminar series given by Richard Feynman, he was teaching about a technique he developed: Quantum Electro-Dynamics. He gave a series of lectures at McGill that lasted two weeks. Interestingly he started with the concept that 'Nature abhors a vacuum' and redeveloped the concept starting with geometrical optics until we emerged with QED. I was hooked! I got really well in tune with him and he said, 'you should stop this engineering and continue physics'. As suggested I applied to Cornell and was accepted. I started at Cornell—there is a very close relationship between University of Montreal and Cornell, which I didn't know before, with lots of exchanges between the universities. Cornell had many faculty that are Nobel Laureates like Hans Bethe, and visiting faculty Richard Feynman and a few other people. It was quite exciting, but I also did engineering over there - I did aerospace engineering, planetary physics and astrophysics. I then returned to Canada so I could finish my service in the Armed Forces with the Defence Research Establishment in Val Cartier near Québec City.

"It is a great honor to receive the 2016 CAP-INO Medal in Applied Photonics, as a professional physicist in biophotonics and photonic materials science, but also as an entrepreneur of many corporations involved in industrial applications of physics. I am all the more delighted by this honor from the Canadian Association of Physicists as it underlines many years of work for solving technological problems and making significant commercial products for both the market and society."

RF So, this was something that you started previously, the service?

RB Yes, I was a Royal Canadian Engineer for a time, prior and during college. So, I came back to Canada and I did go to DREV to work in aerodynamics and missiles but then I moved on to teaching engineering at the University of Sherbrooke, initiating a novel Aerospace Engineering specialty there. I left to help create a company in space engineering and space technology in Ottawa named Canadian Astronautics Limited. It grew to about 200 people by the end of the 80s. It was sold to MacDonald Dettwiler Associates, which was essentially John MacDonald and a few friends at the time. I continued on thereafter with different companies, but I've always been an entrepreneur at heart, so was involved with quite a few successful start-ups. I've worked in all sorts of fields, mining, processing of materials, semi-conductor production, semi-conductor design, new materials, carbon nanotubes, graphene, and then in biomedical imaging. I developed a series of tools in femtosecond time-dependent biomedical imagery.

RF So, what stimulated each of these? Did some idea came to you or something like that?

« C'est un très grand honneur de recevoir la Médaille en photonique appliquée 2016 de l'ACP-INO, en tant que physicien professionnel des sciences de la biophotonique et des matériaux photoniques, mais aussi en tant qu'entrepreneur de plusieurs corporations impliquées dans les applications industrielles de la physique. Cet honneur de l'Association canadienne des physiciens et physiciennes me réjouit d'autant plus qu'il souligne plusieurs années de travail destiné à résoudre des problèmes technologiques et à faire des produits commerciaux significatifs tant pour le marché que la société. »

RB Well, generally yes. What I do is I find a problem which is important in my perspective, relatively untouched by recent science and that is generally situated at the interface between two or more sectors of science. I like to work at the interfaces; they are fertile ecosystems to develop new technologies. I guess one example of this is between biology and quantum optics such as in tissue bio-optics. I tended to concentrate very much at the interface where I can find a way to grasp a problem mentally and be able to imagine a solution and develop a vision. Then comes the hard part; convincing others of its value. But this gets easier with each new venture.

RF Where did you get the support to start on each of these ventures?

RB Well, the first one I started with friends and family. So we all put money in and did not pay ourselves. Over time more and more investors accreted on. Afterwards, people who have been with us in previous financing return into the next venture. Nowadays, this not even an issue.

I have two new start-ups on the go right now and two more in the incubator, where I am at the research phase in collaboration with various research centers and universities.

RF So, are there different venues where you look for new ideas or do you find that you have enough self-inspiration?

RB That's a very good question. I don't know if such venue exists, but I do have to find myself involved into a problem deep enough, focussed enough, for inspiration to emerge. Deep diving. I have to relearn the physics, reteach myself the science every time and then I understand and can create myself a mental model. At one time or another, I get a good idea of what would work and not work mentally, without having to rely on models, books or equations.

That is when I am at the most creative. Bouncing ideas on close collaborators is the catalyst however.

RF So, you get more of an intuition, understanding or feeling?

RB Yes, but intuition happens only after a lot of hard focussed work. Happiness to a large extend for me is the ability to focus.

One must have an intuitive understand what to do for progress to occur. Sometimes you don't understand what you do, but you get a feeling of how it could work and that's usually sufficient to get an innovation going. Then learned guess and failure iterations will get you to the end.

RF So, how would you advise young entrepreneurs to build their experience and get started?

Being an entrepreneur is, to a certain extent. a learned attribute, but the drive is not. You either have the drive or you don't.

RB Well, firstly, most people do get the gist, the spirit of being an entrepreneur from the beginning. They love the freedom and the fast pace action. Being an entrepreneur is to a certain extent a learned attribute, but the drive is not. You either have the drive or you don't. The drive to be an entrepreneur is innate. It is the ability to get back up repeatedly and continue pushing forward that makes a sustainable entrepreneur.

RF Did you have a mentor when you started? Were there some figures that really inspired you in the beginning?

RB When I started, it was in the days that Quebec did not have many entrepreneurs, so I mostly worked with people that were my age and we started developing companies and learning from the ground up by making a lot of mistakes. I keep telling people that the scars on my back are my schooling credentials. Nowadays, there are many coaches about. I went and did an MBA in the latter part of my career and I found out that an MBA is very good when you have prior first-hand experience of the class material, I would never recommend people coming out of school going directly into an MBA program. It's a waste of energy and time, management skills can be learned but it requires a good experience foundation for it to take hold.

RF But, to a large extent entrepreneurship is about having the will to go through it,

RB And stick to it. There is still a factor of chance or luck in growing a technology start-up, some first time entrepreneurs may just be lucky. However sticking to the project enables one to increase the chances of success. Many investors, as a matter of fact, will seek to invest with entrepreneurs that have failed and learned and have resilience, as they are higher on the learning curve and their chances of success are noticeably better.

RF You must have the confidence that some things are going to work out.

RB That's not totally true, because at one time or another in the whole entrepreneurial life-cycle you'll feel like you're going to fail, but you have to have confidence that the idea that you're promoting is the right one and that you're doing it for the right causes. If it's only an idea about making money, then you may not be an entrepreneur. Entrepreneurs want to change something or do something differently.

RF Getting to your current award, what were the things that led to the award that you have now?

RB When I was a venture capitalist at the Caisse de dépôt et placements du Québec, which at the time was the number one or number two pension fund in Canada, I was involved in industrial technologies venture investments. Industrial technologies is essentially everything that is not a bug in a test-tube or shrink-wrapped software. It involves energy, new materials, medical devices and transportation. I reviewed hundreds and hundreds of business plans, evaluated companies and management before I started making capital investments. One of my first investments was a laser-based biophotonics technology company and I found out that the company's technology was not up to the market's expectations, so I decided to leave the Caisse and join the corporation to spruce up and deliver the products. I involved myself deeply into what the company was doing. It became successful with products selling well.

RF What attracted you to get involved with the Polar Knowledge Canada?

RB One time or another, one must to give back to the next generation of leaders. I've arrived to an age, where I've been on the boards of 30 or so corporations and organisations, and people seek my advice on different boards. So, I was approached by the government about this board. Previously, I served on the Atomic Energy of Canada board and on the Space Advisory board. So, this project made sense to me and I'm extremely passionate about all the climate change issues that are occurring. Polar Knowledge Canada has a very challenging mission of great importance coupled with a high dose of science.

RF When did this start? Several years ago?

RB It was year or year and half ago. Prior to becoming the national polar agency, the organisation was known as the Canadian Polar Commission. It is presently building a research station in Cambridge Bay to serve science and research in filling our knowledge gaps about Canada's north and Antarctica.

The first year started with in depth discussions with the PKC (Polar Knowledge Canada) team and board on what needed to and could be done by the agency and its national and international partners. For example; how can one enable more affordable energy to the northerners. More recently, I've been quite interested in the methane that could be extracted from permafrost to improve people's life up there, as well the impact of the permafrost-locked methane release on climate change.

RF What do you see as the goal?

RB We are lacking critical information—critical knowledge—about the poles. How the poles will change the planet's environment and vice-versa. The issue of ice melting, the issue of permafrost melting, and the issue of Greenland ice melting and shedding away and calving out icebergs into the Gulf Stream, those are all issues we don't fully comprehend. We do need to understand these phenomena as they will affect our livelihood.

Are they going to be taking oceanography, the biosphere, and climatology and climate science by storm or will they have a small effect on our daily life? We can't tell at this point in time, because the interlaced sub-elements of earth's system are so very complex and the little information we presently have about the poles. However, we have hunches and can already make guesses, but we don't have all the information required yet to make sound judgements about what's going to happen or not with further climate change. But, frankly, if any of these large tipping points comes to be, they're going to have a significant effect on our way of life as Canadians and Northerners

RF Do you find the government is supportive nowadays in terms of these enterprises and investigations?

RB Absolutely. Our basic role is essentially the same, we are filling knowledge gaps. But we modified the orientation to deal more with climate change than we did previously as the government has now made it a strong priority.

RF Sounds very positive. In general, how do you find the government in terms of supporting entrepreneurship, start-up companies? Are there things that could be done better?

It's very hard to be an entrepreneur, the market and social penalties for failure are quite harsh. It's even harder to be a young entrepreneur.

RB We must celebrate entrepreneurs in Canada. It's very hard to be an entrepreneur, the market and social penalties for failure are quite harsh. It's even harder to be a young entrepreneur; we have to celebrate and support entrepreneurship actively, integrate it more within our DNA. In Canada, we have a tendency to be a more conservative than our southern neighbours and this results in having a lower rate of entrepreneurship emergence. After all, entrepreneurs are the critical gear transforming innovation into competitiveness.

It is also very hard for financiers who have never seen, like in Silicon Valley, companies go from a value of few hundred dollars to a billion dollars over a few years. They have not often experienced such rapid growth corporate life-cycle pace, so the financiers in Canada are correspondingly a bit more stodgy and risk adverse. They have a harder time placing their capital at risk. Most of the big US venture cap funds are run by repeat successful entrepreneurs who are better equipped to perceive the entrepreneur's vision.

We have a tendency to invest capital as if we were a minor league of the US. There is an institutional finance mantra: that if a company is any good, a US company will buy it. We tend to sell projects off too early in their life cycles and we should foster entrepreneurs and bring them to a fuller and larger success so we can all enjoy, as a country, more pride in ourselves and better productivity.

RF So, in your feeling, is innovation being more successful these days than 20 years ago, less successful or the same? Have we made progress?

RB Again a very good question. I think that we're going through a phase in our evolution, whereby governments of all levels believe that investing in early research will necessarily lead to a more active innovation economy and, sadly it rarely does. Entrepreneurs will take an idea from research, from all sorts of places and institutions, and bring them to market. They'll put their livelihood on the line to make it happen. That is the kind of commitment that makes companies successful.

The fact is that putting more money into research is not necessarily going to lead to more competitiveness. It is like pouring more fuel in a car engine, which does not have the drive train in gear, it generates a lot of heat, carbon and noise but leads nowhere fast. Granted, it will lead to additional innovations, but provides little or no traction towards where Canada needs to be in order to maintain and improve our quality of life.

RF You've also been involved in teaching in various stages of our career. Do you enjoy teaching?

RB I love teaching. I think teaching is the basis of everything. If you want any lasting changes to occur it has to be done through teaching. You can preach as much as you want for climate or economy change for that matter, people will initially respond to the impulse for a short period of time as Newton tells us, but when you teach children and even graduate students and under-graduates for instance, they live it. They incorporate it in their daily lives, into the culture. That's why we're presently observing resilient changes in our behaviour towards the environment, about 25 years – or a generation - after we started including environment in our teachings. I strongly believe that education is the foundation of how change management occurs in our society. So, I choose to spend a lot of time teaching. I've been teaching all my life from the day I was a graduate student till now, I still teach classes or give courses and even supervise graduate students from time to time. It is a about passing on.

You want to find and fuel young graduates as they are well educated but do not yet know that it's not possible to go from A to B; they'll find a way to make it happen.

RF So, have you much interaction with graduate students in your various enterprises?

RB In different enterprises, yes. Young graduates are well educated, but do not yet know that things aren't possible. The first thing you want to do is find and fuel people who don't have a clue that it's not possible to go from, A to B, because they'll find a way to make it happen. Young people have a capability to get in a project and find an alternative way of going from A to B without seeing insurmountable obstacles in their way. A recipe for entrepreneurship may lie in finding young people who are emancipated, who are ready to go and giving them the tools to move a project forward. Let them work out the issues, get out of their way and let them get things done and they will come out with a product; a product that people will like.

RF Are there any other thoughts in terms of recommendations for young physicists who are looking forward to the working world?

RB Try not to age on a daily basis. One year older does not mean necessarily one added year of experience! Learning new things is what have made humans successful. Learn faster by failing faster. And, this is the main thing, I think it's important that universities promote entrepreneurship. It is difficult for universities to do so, because people who go in academia are not necessarily entrepreneurs. There is a small portion of them that will be good entrepreneurs. But there should be more promotion of entrepreneurship as a way of life in academia. Only one out of five graduate students will eventually end up in academic life. The other four need to do something else. Hopefully, they're not all driving taxis in Calcutta. We must capitalise on these young and highly educated resources, by enabling them to develop new ideas and concepts while they have the energy and the thick skins required to do so.

RF Thank you for sharing your insights with Physics in Canada

CAP Medal for Excellence in Teaching Undergraduate Physics

Médaille de l'ACP pour l'excellence en enseignement de la physique au premier cycle

Recipient of the 2016 Medal / Lauréat de la médaille 2016:

Prof. James Fraser

James Fraser (Associate Professor, Queen's University) is committed to helping first-year students become apprentice-scientists by enabling them to build their own learning community. He has "flipped" his first-year introductory physics class, challenging his 200 students to take more responsibility for collecting information ahead of lecture so in class they can focus on understanding and applying it. Lecture topics are set by areas that students identify as problematic and class time is spent in Socratic discussion in small groups, with the flow of the lecture set on-the-fly by student needs. Fraser strives to continuously improve the learning environment through student surveys and pre-and post-testing to measure teaching effectiveness. Learning gains are more than double the results achieved with traditional lecture delivery. Students are very supportive of these changes, and Fraser has been recognized through numerous teaching awards including the Queen's Alumni Award for Excellence in Teaching (2012) and the Chancellor A. Charles Baillie Teaching Award (2015). Fraser's first-year physics course also acts as a "demonstration site" for fellow faculty to observe large-class active learning.

Fraser is very active in the dissemination of research-based instructional strategies, through presentations and workshop facilitation both at Queen's and elsewhere in Canada, USA, and Central America. Workshops are designed using the best practices used in courses: participants complete an online survey after doing an advance reading, with the topics of the workshop set by their specific concerns. In the workshop, feedback from participants through a classroom response system or flashcards allows the workshop to change on-the-fly to meet their needs.

Fraser is also a contributor to physics education research through graduate student supervision and collaboration with education researchers. Topics currently being explored include: bridging the gap between physics education research and frontline teaching, overcoming the gender gap in first-year physics, and improved training to help TAs develop into teaching professionals.

The 2016 CAP Medal for Excellence in Teaching Undergraduate Physics is awarded to James Fraser, Queen's University, for being a leader in adopting innovative teaching pedagogies, in developing new teaching methods, and in his scholarly approach to researching the effectiveness of his new methods. Recognized as a top, inspirational teacher by students and faculty alike, his contributions to excellence in undergraduate physics teaching span the range from engaging first-year students as apprentice scientists, to guiding upper year students in their transition to independent scientists, to actively facilitating faculty adoption of research-based instructional strategies, and to bridging the gap between practice and Physics Education Research.

La Médaille de l'ACP pour l'excellence en enseignement de la physique au premier cycle 2016 est décernée à James Fraser, Université Queen's, pour avoir été un chef de file dans l'adoption de méthodes d'enseignement novatrices, l'élaboration de nouvelles méthodes d'enseignement et une façon érudite d'étudier l'efficacité de ses nouvelles méthodes. Reconnu par ses étudiants et ses collègues comme un enseignant de premier plan et une source d'inspiration, le professeur Fraser a fourni un apport à l'excellence en enseignement de la physique au premier cycle qui consiste à engager les étudiants de première année à devenir des scientifiques apprentis, à les guider l'année suivante à devenir indépendants, à favoriser activement l'adoption, par les professeurs, de stratégies d'enseignement fondées sur la recherche, et à combler l'écart entre la pratique et la recherche en enseignement de la physique.

Interview with James Fraser, June 2016 (By Béla Joós)

BJ: Congratulations, James, for the award. It's actually interesting that it goes to somebody who is not a long time veteran. Your citation focuses on the interesting things you've done for education in physics. It doesn't say anything about your trajectory as an academic or a researcher. Could you summarize the relevant facts of your personal trajectory to where you are now as a physics professor at Queen's.

JF: I would say I'm very similar to many people in terms of I had very little formal training as a teacher. Part of my trajectory was to try and take an experimentalist approach to teaching. So instead of working just purely from anecdote or what I thought was working, I tried to get the best quality data from the classroom to try to optimize the teaching to optimize learning. A lot of that was me trying to observe others, talk to others, read what I could from the education literature, but I find the education literature very incredibly diverse. It's a challenge to actually get into it, so it was more a case of seeing what other people were doing and seeing how it could work for my students at Queen's.

"I am extremely honoured to receive this award from the Canadian Association of Physicists. I would like to thank my colleagues and graduate students for the many thoughtful discussions and in particular, I would like to thank my Queen's support staff, graduate student teaching team and the undergraduate students who have been willing to walk with me in this enterprise."

BJ: Okay, I actually meant even going further back, what brought you into physics, your high school and personal background. Could you give a portrait of yourself as a person, as a scientist.

JF: Yeah, that is going back. Both my parents were trained in the arts in languages and so myself and all my sisters are all of course in hard sciences. I guess that was our form of rebellion, but no it was certainly a case of—

BJ: maybe just being more in tune with the times. And same with my father's generation, philosophy professor, language teacher, it was the times. The focus was different.

JF: Yeah and certainly, my mother was taught Latin so there's not too much call for that any longer. But I'd say though that if you look at my background, there are teachers everywhere: my grandfather, my parents, my aunts. I'd say that a teacher has the sort of mindset of always asking questions and trying to understand. So that's how I began, I always liked physics. My science fair projects all ended up being in optics. Back at the Ottawa Science Fair at the Museum of Science and Tech, in grade eight I got the best laser-related project award.

BJ: This was where, in Ottawa?

JF: Yeah, I grew up in Ottawa. I went to Nepean High School.

I went to that school because it had a really good science and math program so I chose to go to go to it even though it wasn't my local school. And then I went to Shad Valley.

That was really interesting because it sort of tied in a whole bunch of different things including engineering, entrepreneurship and physics and so I thought those might be interesting pursuits. But in university I just found physics to be the most fun. I liked the problem solving, that you could build up such a beautiful understanding of so many different things from a few basic ideas. That it wasn't about just memorization. So I just really enjoyed it, went into grad school. In grad school I always joked that I had the highest quality of life that you could have because in grad school you're pursuing the area and the field that you want 100 per cent of the time, that's all you're worried about and concerned with, even though sometimes of course it's very frustrating if the experiment doesn't work. But I was at grad school for Toronto. Henry van Driel was my Ph.D. supervisor and certainly Henry was a person who was a great researcher and also a caring teacher. He took his teaching and his service work very seriously.

« C'est pour moi un honneur insigne de recevoir ce prix de l'Association canadienne des physiciens et physiciennes. J'aimerais remercier mes collègues et les étudiants diplômés de nos nombreuses discussions éclairées, et en particulier mon personnel de soutien à l'Université Queen's, l'équipe d'enseignants des étudiants diplômés et les étudiants de premier cycle qui ont bien voulu se lancer avec moi dans cette aventure. »

Then as my postdoc, I ended up with Paul Corkum and Manuel Joffre in France. So I was half my time in France, half my time with Paul Corkum at NRC. And you know Paul, he's just this incredible communicator; he has this great skill to communicate complicated ideas in a very beautiful succinct way. After my postdoc, I became an Assistant Research Officer at NRC but I missed teaching students. I missed the energy of students and I certainly am glad that I came to Queen's. We've got great students and it's a real privilege to have that opportunity to teach them. Sometimes of course they're frustrating. They don't necessarily pick the right choices for themselves but you try and help them as best as you can.

BJ: Yes, Queen's is privileged to have a higher quality of students than many other universities. So you said in your talk that you were given the first year course, is this mostly for science?

JF: I have at the start of the year about 220 students from Arts & Science. Students don't declare their majors until the end of first year, so they get a chance to check things out. My course would have students who are considering majoring in physics, math, or chemistry, and then also I always do get some really interesting students who are life sciences or other fields and they hear about my course and they hear that it's the 'hard' course and that attracts them. Those are always fun students to have in the classroom. And then you have the students who are quite skilled, but under a lot of pressure to go into med school, but are still trying to find their way. It's a huge range in terms of math skills, motivation and trying to reach all of them is a real challenge as you know.

BJ: Right, so what I found striking is that you seem very passionate about teaching. But these, as you know, are very competitive times and my colleagues, especially younger ones are struggling with the balance between teaching and research. They always have this anxiety at every grant renewal about which category of excellence they'll end up in. Although they care about teaching, there is this struggle in terms of how much time to invest in it. You do not seem to have that anxiety or you're handling it very well.

I do a classroom experience which is much more based on what the students need on the fly. So the lecture might change completely in the middle; I have to have ways to deal with the fact that I might not get to all the different content or topics.

JF: I feel it too, but I believe that by being very strategic in where I put my hours, I can get better learning. It's something that I care a lot about and it's one thing that I think the education literature does very badly. They talk about some beautiful new innovation, some way of teaching and they often make absolutely no comment to the number of hours it took to deploy it and I don't think that's fair. So when talking to a beginning colleague what I try to stress is you can do the math in terms of how many hours you have to teach a course. My job is 40-40-20, so 40 per cent teaching, 40 per cent research, 20 per cent service work. So each of them deserve their 40-40-20, but no more and no less. Getting that balance is the real challenge. People think that to be a better teacher, they need to be doing more. Often that doesn't work - We can't do more, so it's a matter of getting rid of some things. There are some things that I thought were important originally and then I learnt weren't important. A case in point, I used to have beautiful lecture notes that I planned out everything so that when I'm in the classroom it's very clear in my head exactly where we're starting from, where we're going to and where we end at and it's all timed. That takes a lot of time to do. I have nothing like that any longer. So I've had to give up that so that I can do a classroom experience which is much more based on what the students need on the fly. So the lecture might change completely in the middle of the lecture and I have to have ways with dealing with the fact that I might not get to all the different content or topics. I mean there's always more content, there's always more topics to discuss—

BJ: Well, the first year textbooks are bibles, right?

JF: Exactly.

BJ: [Chuckles] They're humungous.

JF: Exactly, there's so much in them. But of course if you cover too much that's useless. You are just inundating the students. They're not learning. You might feel good because you're covering all this material but they're not learning.

BJ: So you rely heavily on the textbook. Those are your lecture notes because you're not spending time producing your own.

JF: Exactly. There's always places in the textbook that I'm not happy with, it's not optimal from my point of view, but—

BJ: Are you promoting one in particular for first year physics?

JF: I use one, but I don't think it matters which one I use. I mean there are certain ones—

BJ: They're so good these days.

JF: Exactly, I mean I would love to have the time to make my own beautiful lecture notes that would be exactly the story I want. But where am I going to find that time, right?

BJ: Exactly, yeah.

JF: I'd have to give up on something else or take time away from my family. And they already impacted enough as it is. Originally way back when, for me the important thing was the content. It was all about the content and trying to make the content as perfect as possible. Now, I just take the syllabus, make use of my textbook as the way of delivering content and spend all the time helping the students assimilate, spend all the time answering questions. And the classroom experience is us going through their questions. But you can see they appreciate that so much more. It's no longer me telling them what they need to know. It's me helping them understand what they need to understand.

BJ: Yeah, I think we always underestimate how long it takes the students to really understand what we teach them. I mean first year's already one thing, but once they're in third and fourth year, for instance, I love to teach them thermodynamics because it took me 10 years to understand it. [Chuckles] So imagine what the students in the first year exposed to thermodynamics how much they understand about the whole issue of processes. Have you taught upper level courses?

JF: Yeah, so I do teach a fourth year laser optic course. When I came to Queen's back in 2004, I asked [Head] Dave Hanes if that one was open, that'd be my dream course and I was very lucky to get that because it's right in my field. This is the sort of thing that I can make a real world very easily because of course I'm thinking about these ideas during my research time as well. Way back at the beginning, it was all about the content. I spent a lot of time finding the content. I made beautiful PowerPoint slides, animations. The students thought the slides were the greatest. They thought it was a great course and then I totally got rid of all that because I realized that there wasn't much learning going on by watching me click through slides. So now I have them doing readings. It's a very sophisticated textbook. It's tough going for them. No matter what career they go into whether it's industry or academia, they're going to be reading heavy technical documentation or textbooks or papers and they need to develop those skills. A first year textbook it's made to be very comprehensible. A fourth year textbook, I wouldn't say that's quite the case. It's made to be very complete, very detailed—

BJ: And up-to-date or—

JF: Yeah, exactly. Anyway, so with the fourth year it's kind of funny, the fourth year students who've never experienced my teaching think that this is an approach that will only work for upper year students because they don't think a first year student has the maturity. The first year students don't think this approach would work for the upper year courses because the upper year courses are much more mathematical, much more technical. And in the end, I think the end results show that it works for both. And frankly, you know what the other thing is it's [chuckling] so much more fun. So I had been teaching that fourth year course, I got to a point where it was just in the back of my head. I knew what the slides were; I could go in cold and teach it. And it wasn't fun because it was just the repetition. When I went to the format where I was responding to students questions, it ends up being so much fun. When I get a good question, I say oh my goodness, they don't understand this. I have to help them understand. That's a real motivator for me to think this person has this question and their fourth year and they don't understand this incredibly important concept. So I'd say that that's also the other reason why I like this approach because it's just that much more interesting.

If you cover too much you are just inundating the students. They're not learning . . . It's no longer me telling them what they need to know. It's me helping them understand what they need to understand.

BJ: Well, thank you. No, indeed it's revealing because one always ask oneself how many of these new approaches does one have time to implement, but it relies on the students' willingness to read the textbook. If one third of the class comes to the lecture without having read what was assigned. What do you do about those people? I mean do you just say it's their problem and then leave it at that or do you have tricks to motivate them?

JF: I hate to say it, it requires tricks. I spend a lot of the first week trying to communicate the process, the reason we're doing readings and spending time in class working towards understanding. To work, it still requires as many as possible intrinsic motivations. For every reading I give there is an output. They have to go online. They've got to answer a question. The most important question is tell me what you found most difficult about the reading. So I think that's useful—

BJ: So this is an online quiz?

JF: Yeah, exactly. Yeah, through Moodle or through some other learning management systems. I think that helps because it communicates to the students, I don't want them to do the reading to master the reading. That's really too high, that's too hard. I just want them to do the reading to figure out what they really don't know, what's the hardest thing. And then, they tell me that on that online quiz. In class, I show them a typical question from their reading and that's what we proceed to discuss. So there's a motivator that they see that by doing the reading and giving me some good feedback, they control the lecture to what they need. And then the other aspect which I find really interesting is I do a lot of peer discussion. One-minute, two-minute break into discussion, discuss this point. And I have had students tell me that this motivates them to do the reading because they don't want to look stupid in front of their colleagues. So even though I'm not asking them to master the material in the reading, they should be at least at the point that they can have a good discussion for one-minute or two minutes on a particular question I ask. And so there's that sort of motivation to be able to contribute to that discussion because every single one of them is in the discussion. Even with my class of 200 students, if there's a group that's quiet, I'm up there talking to them very quickly. So the students learn if they don't want to talk to me, they better just talk to each other. It's much more straightforward.

BJ: Right, so these online quizzes they have deadlines allowing you have time to go over them before the next class?

JF: Yeah, yeah. For me this works well, I don't mind if the deadline's 10pm the night before the lecture. And then I'll spend an hour before the lecture looking at their comments. I already know the material and I can already sort of guess ahead of time what the tough things will be, but still, I think it's really valuable that it's all situated in their questions and their misunderstandings and that I think is a huge motivator to get them to read it. And then also, I don't cover all the material in class. I make it very clear to them, we're only going to cover the things that are hard, so if you don't do the reading and figure out the easier stuff, then the class isn't going to be nearly as effective for you as it could be. I still don't get 100 per cent. There's no doubt about it. Well in the upper year course, I would say it's sort of 90 per cent would be doing the reading. In a first year course, it'd be closer to 80 per cent. Do I worry about the 20 per cent that aren't doing the readings regularly? They of course tend to not do well in the course. I try to give them additional motivation: the very first test, I will report back the results and I'll show them just some aggregated results. The students who had been doing the readings got on average As. The students who weren't doing the readings got Cs. So again, I try to give feedback to the students, give them information about how things are going so that they can do course correction and so that they can figure out what is the best way for them to learn. That's I think really important for first year students. I think a lot of first year is just for the student to figure out how they can actually learn. So I try to give them a lot of feedback so that the ones that are doing it well realize that they're doing it well and they've got to keep doing it.

I do a lot of peer discussion. One-minute, two-minute break into discussion, discuss this point. And I have had students tell me that this motivates them to do the reading because they don't want to look stupid in front of their colleagues.

BJ: No, they want to know what it takes to get an A. [Chuckles]

JF: Exactly, exactly and the earlier I can give them that data, the faster they can correct what they're doing so that they can get the A or that they feel satisfaction out of it. So that's also part of it, just trying to give them a lot of data. I used to only have a midterm but the midterm came so late. Or even weekly problem sets—

BJ: We have two midterms because we always have one which is a retention type of early midterm in early October just to check on the level of understanding of the students, identifying the group of students who really need particular attention.

JF: You know, I think that's really good. I'll say that this is something that I'm not too satisfied yet with my teaching. We've been experimenting a bit. We went to weekly quizzes last year.

BJ: In class?

JF: In the tutorial.

BJ: Okay, during tutorial time.

JF: Yeah, and using some really nice software which basically they write the quiz by themselves and then they redo the exact same quiz as a group. And then when they do it as a group if they get it wrong, the program would say no you got it wrong. So again, it was really meant to be a teaching quiz. That aspect kind of worked but the point that you said about how you use that first midterm to really get students I'd say quality feedback on how things are going for them, it didn't work very well. So we're redoing things. We're going to change it again to go to something that's I'll say a little bit more summative assessment early in the term. It's this challenge of balance: students learn well in groups but at the end of the day, they have to be individually accountable. So finding that balance between group work and individual accountability is what I'm still struggling with.

BJ: So just to move on, you're showing me ways in which to make this workable even for a busy person to stay within the time allotment that you can afford to spend on teaching. But in the citation one reads that you're very active in decimating instructional strategies, which means you're going beyond just doing it. You're actually trying to collect what you've understood or read or keep studying research-based instructional strategies, so you're getting close to the community of professional educators and education research?

JF: Yeah, actually I was really happy, I just heard last week that we have an education paper accepted for the American Journal of Physics. And so I'm happy about that. I actually had a graduate student in physics education research who did her master's in science. First off, she was—

BJ: You were her supervisor?

JF: Yeah, I was the supervisor. So that was a bit unusual. I'd say that that's not a normal thing. At least at Queen's it's certainly not normal. But she was a student who was an A+ student in physics so she had all the credentials. No one questioned her ability—

BJ: No, but you have a program for these people or it's not an official program?

JF: It's not an official program.

BJ: So it's still a master's in physics then.

JF: Yes, yeah. That's always a question about education research in physics, is that physics or not? I certainly have an opinion on that. I would say that it's an important part of our job teaching physics, so if we can do quantitative analysis of teaching, I think of that as physics. But anyway, NSERC doesn't though. I can't use NSERC funds to support research in physics education. Anyway, that's—

BJ: Yeah, that's one of the challenges of education research in physics. There are faculties hired specifically for that purpose. And the challenge they face is funding and recognition.

Education research in physics: I would say that teaching physics is an important part of our job, so we should do quantitative analysis of teaching. This is a place where the American system does much, much better; the NSF clearly sees this as being a very important research area.

JF: And this is a place where the American system does much, much better. I mean NSF clearly sees this as being a very important research area. But I've benefitted so much from education research. We're trying to give back. But then there's this other part that I'm very committed to is that as you were saying, our frontline faculty are very busy. They can't go and start spending a lot of time reading various papers. And I think that the way to show different teaching techniques is to have people experience it. I think that's a very efficient use of time, like in a few hours, I can do a workshop on something like peer instruction and people will get it. They'll understand how it works and why it works from just that few hours of workshopping. So now basically anyone who invites me, if I have time, I will go. I just had a really very neat situation. Just on Friday, I got back from Nicaragua doing a one-day workshop for STEM professors at the UNAN. And trying to give them ideas on different sort of teaching techniques that they could use because they have certain challenges that they're really, really trying to overcome. Frankly, it's a lot of fun too. I mean really interesting discussions.

BJ: Great. Now, I think we can slowly wrap it up. Your experience is encouraging. You show us how to improve the learning experience by simple methods without extensive buildup although technology has really given you help. One of my colleagues that uses Mazur's peer instruction technique, always starts the class with a 5-minute quiz just to check that the students read the material. So now you're doing this online which is definitely a saver. Assignments also done online or is it still paper-based?

JF: So in the fourth year course, I'm still having them do, somebody would say old school, questions on paper and working through the analysis. Though I will say that in the fourth year course, every assignment I give them has a very open-ended, very rich question that I encourage them to work in groups on because it's too open-ended for just one person to work on. And the first year, that's something I'm still trying to optimize. I've gone now to fully online using one of the publishers' products. For a lot of students, it works very well. I worry about the students who short circuit it. They Google the question and they're fooling themselves into thinking that they're actually learning anything.

BJ: They're not going through the thought process.

JF: Yeah, they're missing the thought process completely. But the students really love the immediate feedback that Mastering Physics gives them, so that's really important. The other thing that we did last year which I think worked well and we'll keep doing it, is we integrated our labs and our tutorials into one thing. And that worked really well instead of it being what it used to be traditionally one three-hour block that was a lab, one week and then a three-hour block that was a tutorial a different week. Now, we've made it seamless and they have just one TA working with them for the entire time, so that works out really well.

BJ: Okay, many universities have a heavy teaching responsibility and more and more think that the solution to making sure that the first year of teaching is done very well is to have dedicated teachers or professors who will invest the time to develop first rate educational material. This relieves the pressure from research focussed faculty ensuring that the department fulfills well its teaching and research missions. Should we have these two kinds of teachers and, should teaching research be part of the responsibility of an ideal department?

JF: I think that's really interesting - if we were able to make teaching research part of everyone's job. Your first point about dedicated teaching staff, I have to be careful about that since I know many primarily teaching staff and they do a great job and I have learned a lot from them. I'll say though I do have a really strong feeling, at least with my experience with students that students really want to know what it's like to be a physicist. They want to hear about the research I'm doing. They love talking with the TAs about what research they care about and what they're doing. I see myself hopefully as a mentor to be a physicist, as well as a teacher.

BJ: Well just to finish, how do you balance your life? I mean it would be interesting to hear what you do to relax or your hobbies? [Chuckles]

JF: I have a wife and two sons. And so occasionally I'll try questions out on them and they have fun with that, my sons, my wife not so much. I have the same struggles as everyone else trying to make the family time just dedicated to family time. Other hobbies. The sports I end up doing are sports that I can do with my sons. And now the big one for us is speed skating, so we are very active in the short track speed skating which is a very interesting physics problem in terms of how you manage to accelerate around a corner that has a tight radius.

BJ: And the maximum angles before you slip. [Chuckles]

JF: Exactly, if you start thinking about it too much in the curve you fall.

BJ: Well thank you, James that was great talking to you and good luck. You're an inspiration to us older folks. [Chuckles]

JF: I'm sure that there are still things that I'm doing wrong that I am trying to find better ways of doing. I just keep learning.

BJ: Excellent, thank you.

JF: Alright, so long.

CAP/DCMMP Brockhouse Medal

La Médaille Brockhouse de l'ACP/DPMCM

The 2016 CAP/DCMMP Brockhouse Medal is awarded to Carlos Silva, Université de Montréal, for his original developments in transient optical spectroscopies which have brought deep insights into the understanding of electronic excitations in molecular semiconductors.

La Médaille Brockhouse 2016 est décernée à Carlos Silva, Université de Montréal, pour ses avancées originales qui, en spectroscopie optique transitoire, ont donné des visions profondes sur la compréhension des excitations électroniques dans les semi-conducteurs moléculaires.

Carlos Silva, Professor of Physics and University Research Chair in Organic Semiconductor Materials, enjoys international recognition as a leader in the development of the physics of polymeric and hybrid semiconductors by means of time-resolved optical probes, especially ultrafast spectroscopies. He focuses his current research efforts on exciton and polaron dynamics in polymeric semiconductors and novel hybrid materials such as perovskites, and strong coupling of light and excitons in organic semiconductor optical microcavities. Several of his publications have become landmark papers that have triggered widespread experimental and theoretical research by groups throughout the research world. What characterizes his contributions is a unique combination of materials processing know-how to study the appropriate sample for the problem at hand, with state-of-the-art experimental and theoretical approaches that open the door for new understanding.

Recipient of the 2016 Medal / Lauréat de la médaille 2016:

Prof. Carlos Silva

Professor Silva obtained a PhD in chemical physics from the University of Minnesota in 1998, after which he was a postdoctoral research fellow at the Cavendish Laboratory, University of Cambridge. In 2001 he became Advanced Research Fellow of the UK Engineering and Physical Sciences Research Council at the Cavendish Laboratory, as well as Research Fellow in Darwin College, Cambridge. Attracted by the professional opportunities provided by a Canada Research Chair and by the academic environment at the UdeM, he moved his research program in January 2005. In Montreal, he has set up a unique facility for ultrafast spectroscopy of advanced electroactive materials, which, in conjunction with his recognized expertise, attracts a large number of international collaborations.

Remarks by Carlos Silva

It is a great honour to be recognized by the CAP/DCMMP by the 2016 Brockhouse Medal. It is also very humbling to be on the same list as such eminent Canadian condensed-matter physicists who are past laureates. This is undoubtedly recognition of the talented and committed research students and postdocs in my group, who are the ones that have produced the science that has been acknowledged. I am very grateful and thankful to them. One of the most rewarding and indeed fun aspects of our academic job is the daily contact with such talented scientists in the making. I am also extremely grateful for the supportive and collegial environment of the Université de Montréal and the Department of Physics. It is such a pleasure to work alongside scientists of such calibre and such humanity. I want to acknowledge in particular my colleagues Richard Leonelli and Michel Côté, who have not only been excellent collaborators and colleagues as researchers, but have been key in helping me become a better teacher. In this respect I also thank warmly my colleague Sjoerd Roorda.

"It is a great honour to be recognized by the CAP Brockhouse Medal, and a great testament to the talented research team with whom I have the pleasure to work."

« C'est pour moi un grand honneur d'être reconnu par la médaille Brockhouse de l'ACP et un précieux témoignage à l'équipe de chercheurs talentueux avec lesquels j'ai le plaisir de travailler. »

The work that was highlighted in my Brockhouse Medal nomination is the fruit of very successful collaborations with several close colleagues and friends. In particular, I highlight work done closely with Professors Natalie Stingelin, Imperial College London, and Frank Spano, Temple University. Together, we have addressed a fundamental question in the science and technology of macromolecular semiconductors – how are electronic properties driven by the very diverse and complex solid-state microstructures that polymers can adopt? As the materials properties such as molecular weight, and processing protocols are varied, the electronic properties change significantly as well. We have focused on the properties of excitons and polarons in this class of materials, combining advanced materials processing techniques with ultrafast and steady-state spectroscopies, and theoretical models to unravel exciton coherence lengths, exciton dynamics, and the evolution of excitons into polarons and back. With collaborator and Friend Eric Bittner (University of Houston), we have studied the mechanism of photocarrier generation in this class of materials. The rate of formation of photocarriers appears to be ultrafast (<100 fs) – why given the dielectric environment of these materials? We have combined ultrafast vibrational and coherent multidimensional spectroscopies to address this question.

Canada is such a wonderful environment in which to do science. I am grateful to the CAP for what it contributes to making it so.

CAP Herzberg Medal

La Médaille Herzberg de l'ACP

Dr. Roger Melko is a pioneer and world leader in the modern multidisciplinary field of quantum many-body physics. He has made major contributions to our understanding of strongly interacting condensed-matter systems through large-scale computer simulations. The innovative new models and algorithms developed by Melko have enhanced the reach of computational methods and enabled the exploration of new physical phenomena.

Recipient of the 2016 Medal / Lauréat de la médaille 2016:

Prof. Roger Melko

Through the creative use of cutting-edge simulations, he has produced numerous groundbreaking results, including identifying exotic new phases of quantum matter, characterizing quantum phase transitions, and demonstrating emergent topological phenomena. His development of an innovative new approach to evaluate entropic measures of entanglement with quantum Monte Carlo simulations in 2010 was a breakthrough. His methods are now widely used and, as a result, entanglement is now broadly recognized as a useful diagnostic in the study of quantum matter by condensed matter physicists around the world.

The 2016 CAP Herzberg Medal is awarded to Roger Melko, University of Waterloo and Perimeter Institute, for his contributions to theoretical condensed matter physics, particularly large scale computer simulations which elucidate timely issues in the physics of strongly correlated electronic systems.

La Médaille Herzberg 2016 est décernée à Roger Melko, Université de Waterloo et Institut Périmètre, pour son apport à la physique théorique de la matière condensée, notamment les simulations informatiques à grande échelle qui éclairent les enjeux actuels de la physique des systèmes électroniques fortement corrélés.

The ability to study entanglement with quantum Monte Carlo techniques has facilitated new synergies between a variety of fields, including topological quantum computing, quantum field theory, and quantum gravity. Recently, using his new approach, Melko discovered and characterized new universal physics in quantum critical theories. This work has far-reaching implications for the theory of quantum phase transitions, renormalization-group fixed points, and the relationship between the underlying geometrical structure of correlations in conformal field theories and their higher-dimensional gravity duals.

Remarks by Roger Melko

It is a tremendous honor to receive the 2016 CAP Herzberg Medal. I'm delighted by this recognition, which reflects the value that the Canadian physics community places on computational research, particularly in the field of quantum many-body physics.

"It is a tremendous honour to receive the CAP Herzberg medal, and a humbling experience to join past recipients whom I have long admired and respected. This award recognizes the talented work of my many collaborators and students. My deepest appreciation goes to CAP for the value this organization places on our Canadian physics community."

« C'est pour moi un très grand honneur de recevoir la médaille Herzberg de l'ACP et une belle leçon d'humilité de rejoindre ces anciens lauréats que j'admire et respecte depuis longtemps. Ce prix témoigne des travaux talentueux de mes nombreux collaborateurs et étudiants. Mes remerciements les plus sincères vont à l'ACP pour l'importance que cet organisme accorde à notre communauté canadienne de la physique. »

This is a field of physics concerning problems that contain a high degree of complexity, like high-temperature superconductivity and quantum magnetism, and thus spurn the simple approximations that allow most analytical theoretical treatments. Thus, it is typically necessary to employ computer simulations, both to model experiments, and as a stand-alone tool for theoretical investigations. It was through my MSc supervisor Michel Gingras that I first appreciated the power of computational techniques, especially Monte Carlo simulations, applied to condensed matter physics.

When considering US schools for my PhD, I was lucky enough to be welcomed into the wonderful group of Doug Scalapino's at the University of California, Santa Barbara. A pillar of computational research in high-temperature superconductivity, Scalapino fostered a close-knit company of students and postdocs who were like-minded in their appreciation of computer simulations as a primary tool for the theorist. I benefitted tremendously from this inspiring group of people, especially Anders Sandvik, under whom I apprenticed in the intricate art of quantum Monte Carlo (QMC) in the early years of my PhD.

Near the end of my PhD, I became aware of the fascinating progress being made by a very different community, the quantum information theorists. They were investigating why some quantum many-body problems are capable of being efficiently simulated on conventional computers, while others are not. Specifically, ideas relating the structure of quantum entanglement to simulation capability sparked my curiosity. In 2005, I was lucky enough to find a stimulating environment at Oak Ridge National Laboratory, where during a heady two years, my friends and I began to explore the underlying connections between problems in condensed matter physics, computer algorithms, and quantum information theory.

I returned to Waterloo as faculty, a product of incredible luck and timing, with a very new sense of where I wanted to take my research. The important role that entanglement played in the physics of many-body systems was becoming very clear to me. However I was struck by how little we, as a community, knew about entanglement in even the simplest models of condensed matter. The key that allowed me to contribute to this problem came from Matthew Hastings, who impressed upon me the innate ability, yet undiscovered, of my favorite numerical technique (QMC) to calculate a measure of quantum entanglement called the Renyi entropies. Since 2010, this new measurement has provided an incredible wealth of information about the delicate quantum correlations that exist in materials and matter at very low temperatures – a perspective that is very much complementary to traditional approaches in condensed matter physics.

This emerging view of quantum matter married with information theory opens a vast landscape of possibilities for the study of entanglement and related phenomena in many-body physics. This includes not only my old field of condensed matter, but also quantum information systems (such as quantum computers and other devices), atomic physics, and even the arenas of quantum field theory and gravity. Going into the future, the understanding of entanglement as a unifying concept will be forged, in my (surely biased) opinion, increasingly by computational approaches. The upcoming generation of physicist will have to master both the traditional (and necessary) mathematical tools of the trade, as well as the non-traditional (and rapidly evolving) tools of simulation. It is my hope that this recognition by CAP will help inspire the next generation of young physicists for whom untold breakthroughs lie in wait.

Finally, a sincere thank you to all of my past mentors (some, but not all, mentioned above), students, and colleagues, who know from working with me that I would achieve nothing without the constant stimulation, discussion, and collaboration that occurs when I am surrounded by my friends. Also, to my family, always supportive despite presumably wondering where I am and what I am up to. Finally and most importantly, to my amazing wife Lori, who plays the biggest role in keeping me in the physics life to which I have become accustomed, and to whom I dedicate this award.

CAP Medal for Lifetime Achievement in Physics

La Médaille de l'ACP pour contributions exceptionnelles à la physique

Digne héritier de la tradition d'excellence dans le domaine de l'astrophysique au Canada, le professeur Fontaine s'est distingué sur la scène internationale pour la qualité exceptionnelle de ses travaux de recherche en astrophysique stellaire, particulièrement dans l'étude des phases finales de l'évolution stellaire (étoiles naines blanches et sous-naines), ces produits ultimes de l'évolution stellaire pour la grande majorité des étoiles. Il a non seulement jeté les bases d'une véritable théorie de l'évolution des naines blanches, mais il est aussi un des pionniers de leur utilisation comme cosmochronomètres indépendants des différentes composantes de notre galaxie. Il s'est également imposé comme chef de file dans le domaine de l'astérosismologie, cette méthode unique permettant de sonder la structure interne des étoiles par l'étude de leurs « tremblements d'étoile », en combinant à la fois observations et modélisation numérique. L'ensemble de son œuvre scientifique, qui fait école dans le monde, lui a valu de multiples prix et récompenses.

Auteur prolifique, le professeur Fontaine s'est aussi consacré de façon remarquable à la formation de scientifiques de grand calibre. Plusieurs de ses anciens étudiants ont obtenu des prix régionaux et nationaux pour la qualité exceptionnelle de leur thèse de doctorat. Ayant bâti une équipe de recherche de renommée mondiale, monsieur Fontaine a pu attirer plusieurs étudiants étrangers pour les cycles d'études supérieures. Enfin, il a démontré de plus d'une façon être un enseignant hors pair et un excellent communicateur. Par ces actions, il a sans aucun doute suscité de nombreuses vocations scientifiques.

Recipient of the 2016 Medal / Lauréat de la médaille 2016:

Prof. Gilles Fontaine

The 2016 CAP Medal for Lifetime Achievement in Physics is awarded to Gilles Fontaine, Université de Montréal, for his pioneering, world-renowned work in theoretical and observational studies of white dwarf stars and the late stages of stellar evolution, including major contributions to the equation of state for white dwarfs and investigations of pulsating compact stars, as well as the discovery of a new class of subdwarf pulsators. His leadership has built what is arguably the preeminent group in the world in this field.

La Médaille de l'ACP pour contributions exceptionnelles à la physique 2016 est décernée à Gilles Fontaine, Université de Montréal, pour ses travaux exceptionnels mondialement reconnus dans les études théoriques et d'observation sur les naines blanches et les derniers stades de l'évolution des étoiles, dont d'importants apports à l'équation d'état des naines blanches et les études sur les étoiles compactes pulsantes, ainsi que la découverte d'une nouvelle catégorie de sous-naines pulsantes. Son leadership a donné naissance au groupe qui est incontestablement prédominant dans le monde en ce domaine.

Entrevue avec Gilles Fontaine, juin 2016 (par René Roy)

RR: Bonjour, Gilles

GF: Bonjour, René.

RR: Bravo encore une fois pour cette belle reconnaissance.

GF: Merci beaucoup.

RR: Je suis fier d'avoir été ton collègue du baccalauréat.

GF: Merci beaucoup, René.

"I am deeply honored to have been selected the recipient of this prestigious national award. I feel privileged to live in a country where I could fulfill my teenage dreams of pursuing a research career in physics."

RR: Donc si on recule un peu justement, pourquoi as-tu choisi la physique?

GF: J'ai commencé, comme petit garçon, à observer le ciel suite à l'exploit de Spoutnik 1. En regardant les satellites passer, j'ai « découvert » les étoiles et cela m'a marqué profondément. À l'école secondaire, chez les Frères Maristes à Lévis, j'ai eu aussi l'opportunité de construire un petit télescope et je suis devenu un astronome amateur. Donc, mon intérêt premier, c'était l'astronomie, mais quand je suis entré à l'Université Laval en 1965, il n'y avait pas de programme dans ce domaine à l'époque. Mais j'étais déjà fasciné par la physique et je voulais en savoir beaucoup plus sur tous les aspects de cette science. Vers la fin de mon B.Sc. en 1969, un jeune professeur de Laval, M. Gabriel Bédard, m'a fortement encouragé à m'inscrire au *Institute of Optics* (Université de Rochester), une grande école d'optique reconnue mondialement. Ce que j'ai fait, avec l'intention d'étudier l'optique quantique dans le groupe du Prof. Emil Wolf. Mais sur place, au cours de ma première année consacrée essentiellement à des cours de base obligatoires en physique avancée, j'ai suivi un cours optionnel en astrophysique théorique offert par un jeune professeur charismatique, Hugh M. Van Horn, qui m'a convaincu que l'astrophysique, ça pouvait être vraiment, vraiment intéressant! Ce fut une sorte de coup de foudre avec retour vers l'astronomie et j'ai donc décidé de faire un doctorat sous la direction de Hugh.

« C'est un immense honneur pour moi de recevoir ce prix national prestigieux. Je me sens privilégié de vivre dans un pays où j'ai pu réaliser mon rêve de faire carrière dans le domaine de la physique. »

RR: Mais qu'est-ce qui a provoqué un passage de l'astronomie amateur, plutôt expérimentale, à une carrière qui a été, à mon évaluation, plutôt en astrophysique théorique?

GF: Il y a une connexion « naturelle », si je puis dire. Hugh Van Horn était un spécialiste du domaine de la matière condensée, mais appliquée sous des conditions astrophysiques. Sa thèse de doctorat à Cornell traitait des réactions thermo et pycnonucléaires, d'intérêt astrophysique. Donc, tu vois, il y a une connexion super intéressante avec la physique des noyaux. Et pour moi, c'était nouveau. Les étoiles sont des engins nucléaires, des réacteurs nucléaires auto-contrôlés. En plus, à la fin de leur vie nucléaire, la très grande majorité des étoiles s'effondrent sur elles-mêmes pour devenir des naines blanches. Ces étoiles offrent encore et toujours des défis à ceux qui s'intéressent à la physique de la matière sous conditions extrêmes. J'ai trouvé cet aspect fascinant et je me suis donc lancé dans l'étude de ce type d'étoiles. En pratique, on parle essentiellement de modélisation numérique. Ça m'a vraiment séduit.

L'élément-clé de ma carrière de chercheur a été de pouvoir développer des projets de recherche combinant, à la fois, des mesures astronomiques ayant une incidence directe sur mes efforts de modélisation et vice-versa.

RR: Ça m'ouvre la porte : qu'est-ce qui a fait qu'aujourd'hui on a eu la chance de t'entendre donner une conférence en séance plénière ? Quelles ont été les contributions exceptionnelles qui t'ont fait mériter ce prix?

GF: Tout d'abord, il y a un contexte que je me dois d'expliquer. J'ai eu la chance — c'est un aspect important — non pas de me recycler, mais d'ajouter à mon expertise théorique. J'ai appris le métier d'astronome-observateur grâce à un stage postdoctoral à l'Université Western Ontario. Quand j'ai terminé mon doctorat en 1973 à l'Université de Rochester, je suis revenu au Canada pour poursuivre un premier stage postdoctoral à l'Université de Montréal grâce à une bourse du Conseil national de recherches (Le CRSNG n'existait pas encore...). À l'époque, il y avait le grand projet québécois de construction de l'Observatoire du Mont-Mégantic, avec des postes à venir pour des observateurs. En ma qualité de postdoc théoricien, je n'avais pas les compétences requises pour un de ces postes, mais j'ai eu la chance immense de rencontrer un des meilleurs chercheurs dans l'histoire de l'astronomie canadienne, John Landstreet de l'Université Western Ontario. De façon exceptionnellement généreuse, John m'a offert de m'enseigner le métier d'astronome-observateur et il m'a engagé dans son groupe à Western pour un deuxième stage postdoctoral. Nous sommes en 1976-77. Et grâce à la réputation de John dans le monde de l'astronomie, j'ai eu l'opportunité de faire mes premières armes à des endroits très prestigieux comme les Observatoires du Mont-Wilson et Mont-Palomar.

J'ai donc appris un nouveau métier, un peu sur le tas. Pendant un peu plus d'un an, durant mon stage à Western, j'ai complètement mis mes modèles de côté. Au début, ce n'était pas si facile. Je ne savais pas si j'avais pris la bonne décision, mais mon plan, bien sûr, était de pouvoir monter un CV avec un volet « observateur » suffisamment étoffé pour pouvoir postuler pour un des derniers postes associés à l'Observatoire du Mont-Mégantic, un à Laval et un autre à Montréal. Ultimement, via cette stratégie qui fut possible grâce à l'aide inestimable de John, j'ai obtenu un poste de professeur à l'Université de Montréal en août 1977. Pour la suite des choses, j'ai toujours retenu l'immense leçon apprise à Western, i.e., comment apprécier une mesure astronomique. Je dirais que l'élément-clé de ma carrière de chercheur a été de pouvoir développer des projets de recherche combinant, à la fois, des mesures astronomiques ayant une incidence directe sur mes efforts de modélisation et vice-versa.

RR: Mes félicitations pour cette réussite.

GF: J'ai beaucoup investi en astronomie d'observation et j'ai voyagé souvent, à cette fin, particulièrement en Californie, Arizona, Hawaii et au Chili. J'ai pu financer la construction de deux instruments, dont un, toujours de pointe et installé en permanence en Arizona, est une infrastructure de la Fondation canadienne pour l'innovation. J'y envoie tous mes étudiants, théoriciens ou non. L'astronomie d'observation a été très importante dans ma vie parce que je suis devenu un bien meilleur chercheur grâce à cette combinaison théorie-observations.

RR: Donc, vraiment, je dirais que ce fut une réorientation marquante?

GF: Oui, un nouvel acquis fondamental ! Et j'en suis sorti évidemment très enrichi ; je suis devenu un bien meilleur scientifique...

Quelles ont été mes réalisations ? Eh bien, je me suis principalement intéressé à l'étude des étoiles dégénérées (ou naines blanches). Ces objets intéressent tout autant l'astronome que le physicien. En effet, ces étoiles sont de véritables fossiles portant les empreintes d'évènements passés d'importance centrale dans la vie des étoiles (perte de masse, phases de mélange, perte et redistribution du moment cinétique, brûlage thermonucléaire). Elles sont également des traceurs de la structure galactique et indicateurs d'âge et de distance de différentes composantes galactiques. De plus, les naines blanches ont un impact en cosmologie via le processus de formation des supernovae de type Ia (les indicateurs de distance utilisés dans la découverte et l'observation de l'accélération de l'expansion de l'univers) et, plus récemment, elles ont fait une entrée dans le domaine populaire des exoplanètes. Pour le physicien, leur intérêt premier vient du fait qu'on y rencontre des conditions extrêmes de densités qu'on ne peut pas encore reproduire en laboratoire. Les progrès dans la modélisation des naines blanches ont montré que ces étoiles constituent en effet d'excellents bancs d'essai pour les théories d'équation d'état, d'opacité, de coefficients de transport, de formation de raies spectrales et de physique atomique en présence de champs magnétiques dépassant le megagauss en magnitude.

Spécifiquement, je peux prétendre que mes travaux sur l'équation d'état et sur les propriétés de transport dans les plasmas denses typiques de l'intérieur des naines blanches ont marqué le domaine. Je me suis aussi investi énormément dans la caractérisation de ces étoiles, notamment au niveau de la modélisation numérique et de la cueillette de données photométriques et spectroscopiques multi-bandes. J'ai jeté les bases d'une véritable théorie de l'évolution spectrale des étoiles naines blanches, théorie qui continue d'être peaufinée à ce jour. Je suis aussi un des pionniers de l'utilisation des naines blanches comme cosmochronomètres indépendants des différentes composantes (disque, halo, amas ouverts et globulaires) de notre galaxie. J'ai contribué à mettre en valeur le potentiel extraordinaire de cette méthode. Je me suis beaucoup investi dans le développement de l'astérosismologie – cette méthode unique permettant de sonder la structure interne des étoiles via l'étude de leurs vibrations – en participant activement à la découverte de nouveaux spécimens et de nouvelles catégories de naines blanches pulsantes et en les caractérisant. J'ai développé, en collaboration avec deux étudiants, la première méthode quantitative et objective pour la recherche automatique de modèles sismiques optimaux dans l'espace des paramètres. Au cours des vingt dernières années, moi et mon équipe avons aussi investi et développé le champ de l'astérosismologie telle qu'appliquée à une autre catégorie d'étoiles, les sous-naines chaudes (précurseurs d'une fraction des naines blanches), qui se sont avérées être les meilleurs laboratoires sismiques connus couramment. Au total, je m'approche de quelque 500 publications dans ce domaine de l'astrophysique stellaire.

Mais, à mes yeux, ma contribution la plus significative aura été ma participation à la formation de nombreux étudiants aux cycles supérieurs. Plusieurs d'entre eux ont obtenu des prix prestigieux pour la qualité exceptionnelle de leurs travaux, dont la médaille Plaskett de la Société canadienne d'astronomie, remise annuellement pour la meilleure thèse de doctorat en astronomie-astrophysique au pays.

RR: Tu as raison d'être fier.

GF: Oui, très certainement! Et je continue de collaborer avec plusieurs d'entre eux; c'est ce que j'aime faire le plus aujourd'hui! J'ai aussi été témoin d'une transition intéressante : à date, j'ai dirigé 15 étudiants au doctorat, mais les six derniers (ou dernières) ce sont des femmes, alors que mes premiers étudiants étaient des hommes.

À mes yeux, ma contribution la plus significative aura été ma participation à la formation de nombreux étudiants aux cycles supérieurs. Je continue de collaborer avec plusieurs d'entre eux; c'est ce que j'aime faire le plus aujourd'hui.

RR: Donc, je vois que les étudiants, quand ils sont étudiants ou par la suite, ont été d'importants collaborateurs.

GF: C'est ma « famille » et je les appelle «mes fils et mes filles scientifiques»! D'ailleurs, on va se revoir avec grand plaisir, une partie d'entre nous. Il y aura six de mes anciens étudiants à Coventry en Angleterre cet été pour une conférence. Typiquement, on se voit une fois ou deux par année durant la saison des conférences, dépendamment du lieu de la conférence, et je travaille activement avec une bonne dizaine de mes anciens étudiants.

RR: C'est sûr qu'on veut toujours que nos étudiants réussissent et ça devient notre fierté.

GF: Très certainement, comme un papa! Si tu me demandes : « quelle est ta plus belle réalisation? », eh bien, c'est d'avoir contribué à leur formation scientifique.

RR: La relève.

GF: Ça, c'est ça dont je suis le plus fier, très certainement.

RR: Pour arriver là, je peux voir qu'il y a eu des moments forts.

GF: Oui, mais beaucoup de travail. Tu le sais très bien, René. Dans notre domaine : 1 % d'inspiration, 99 % de travail acharné. C'est comme ça que ça se passe!

RR: Oui. Il faut travailler fort, ainsi pour avoir le financement.

Comment ça s'est passé dans ton cas?

GF: Je dois dire que c'était bien, très bien même au niveau canadien et aussi au niveau provincial. On a été généreux avec moi, particulièrement dans le contexte canadien. Mais les débuts ont été modestes.

RR: Est-ce que tu dirais que finalement ta carrière a commencé dans une période où on mettait de plus en plus de financement en astrophysique et que les installations commençaient à ouvrir?

GF: Pas vraiment. Au niveau individuel, ce n'était pas le cas. Oui, effectivement, il y a eu des investissements, entre autres au Mont-Mégantic et au CHFT, par exemple, mais individuellement, ce n'était pas évident et je me souviens de ma première subvention.

J'avais eu un « gros » 10 000 $ du CNR pour un an, mais c'était la norme et il me revenait de faire mes preuves. On commence avec ça et on construit lentement à partir de là. Je dois dire que dans la dernière moitié de ma carrière, un point absolument tournant pour moi, a été l'obtention d'une Chaire de recherche du Canada en 2002. M. Robert Lacroix, recteur de l'Université de Montréal à l'époque, m'avait identifié au sein d'un petit groupe de professeurs jugés performants comme candidat pour une Chaire dite de rétention. J'en suis resté infiniment reconnaissant car cette opportunité allait me donner les moyens financiers de maintenir une équipe minimale, notamment un numéricien exceptionnel (Pierre Brassard, un de mes anciens doctorants) qui nous a fourni à moi et mes étudiants des outils numériques uniques et qui continue de le faire. Entre autres, nous avons à notre disposition une grappe d'ordinateurs très performants de 320 nœuds assemblés ensemble à coûts minimum grâce à Pierre. Sinon, j'ai joui, de façon continue depuis 1979, de subventions individuelles du CRSNG qui ont été généreuses et, aussi, depuis 1988, de subventions d'équipe du FRQNT.

RR: Actuellement, il y a une grande puissance de calcul rendue disponible par le réseau des ordinateurs installés au Québec, est-ce que vous en profitez dans votre groupe?

GF: Non et c'est voulu de ma part ! Ce qui m'a attiré quelques ennuis car j'ai eu de la difficulté effectivement à renouveler nos machines à un moment donné parce qu'on me disait qu'une grande puissance de calcul était disponible dans le réseau. Demander du temps sur les ordinateurs de ce réseau c'est ajouter une couche de bureaucratie à un système qui croule déjà sous celle-ci. C'est très semblable aux demandes, très compétitives, qu'on doit se taper pour obtenir du temps d'observation sur les grandes installations astronomiques internationales. Ça demande du temps! Le temps étant l'item le plus précieux dans la vie d'un chercheur, j'ai toujours préféré le conserver pour la recherche même. Aussi, un leitmotiv dans ma vie a toujours été d'être aussi autonome que possible. Notre grappe d'ordinateurs ne se compare en rien à la puissance du réseau, mais elle satisfait à nos besoins et elle nous est disponible en tout temps. Si, d'ici ce soir, j'ai une bonne idée et je veux lancer un calcul important, personne ne va me dire : « Non, non, tu ne peux pas faire ça. Il faut faire une demande d'abord. » C'est par la FCI en fait, via ma Chaire de recherche, que je peux financer mes ordinateurs.

Demander du temps sur les ordinateurs de ce réseau c'est ajouter une couche de bureaucratie à un système qui croule déjà sous celle-ci. . . . Le temps étant l'item le plus précieux dans la vie d'un chercheur, j'ai toujours préféré le conserver pour la recherche même.

J'ai investi essentiellement en deux parties des subventions d'équipement que j'ai eues pour maintenir ou développer la grappe de calcul et pour financer mon instrument en Arizona.

RR: Ce dernier est-il toujours opérationnel?

GF: Celui-là, oui. C'est un CCD moderne. Je ne l'ai pas payé à 100 %, car c'est un partenariat. C'est une machine qui nous donne accès à un télescope. Ce n'est pas un nouveau télescope, mais c'est un super bon site à 3000 m en Arizona.

RR: Est-ce le plus grand en Arizona?

GF: Loin de là ! En fait, c'est un télescope historique qui a la même dimension que celui de Mégantic; c'est un 1.6 m qu'a développé l'Université de l'Arizona. Il a été construit dans les années 60 grâce à un contrat de la NASA octroyé à l'U. de l'Arizona spécifiquement pour cartographier la Lune afin d'identifier les sites d'alunissage pour le projet Apollo ! Pourquoi travailler là-bas? À cause de la qualité de l'image à cet endroit. Ce site exceptionnel était tombé en désuétude parce que la majorité des collègues de l'Université de l'Arizona ont des projets extragalactiques, et pour eux, 1.6 m, c'est généralement trop petit. Depuis qu'on l'a relancé, le télescope est utilisé à temps plein, avec une demande qui dépasse l'offre. Cet instrument, qui a été baptisé Mont4K (comme dans « Montréal 4K X 4K CCD Camera ») permet de faire de l'imagerie et de la photométrie rapide. Pour ma part, je l'utilise en mode lecture « rapide » parce que je m'intéresse aux variations des étoiles pulsantes avec des temps caractéristiques d'échantillonnage autour de 5 secondes.

RR: Ça pourrait être encore plus rapide, car les CCD le pourraient ?

GF : Oui, tout à fait. On peut aller à une fraction de seconde avec le Mont4K, mais dans mon cas, avec les naines blanches qui sont intrinsèquement peu brillantes, les variations lumineuses dues aux pulsations ont des périodes de quelques centaines de secondes typiquement, ce qui permet d'utiliser un temps d'échantillonnage de 5 à 10 s pour obtenir un rapport S/N décent pour l'analyse de Fourier subséquente.

RR: Puis-je revenir sur l'âge de l'univers ?

GF: Oui, bien sûr. C'est un beau fait d'armes pour moi !

RR: Comment la prédiction avait-elle été faite ?

GF: En fait, le principe est relativement simple. On l'a dit, la majorité des étoiles terminent leur vie sous la forme de naines blanches. Dans notre galaxie, les étoiles de la toute première génération sont aujourd'hui des naines blanches. Or ces étoiles évoluent de façon particulière, de telle sorte que plus une naine blanche est froide, plus son taux de refroidissement diminue.

Il y a donc un effet d'accumulation à très faible température dans le nombre de naine blanches par unité de volume galactique. Cette distribution monotone, par contre, subit une coupure brusque lorsque la température de surface devient plus petite qu'une valeur caractéristique, en dessous de laquelle même les étoiles les plus vieilles n'ont pas encore eu le temps d'atteindre à cause de l'âge fini de la galaxie. Dans les années 80, on a mesuré un déficit réel de naines blanches à partir d'une certaine luminosité (température de surface) intrinsèque. La coupure correspond à un âge que nos modèles de refroidissement de naines blanches peuvent déterminer, avec une bonne précision, pour le disque de notre galaxie, soit environ 10 +/- 1 milliards d'années. En ajoutant 2-3 milliards d'années pour le temps généralement admis entre le Big Bang et la formation du disque galactique, on obtient un estimé de l'âge de l'univers, 12-13 milliards d'années, tout à fait indépendamment d'autres méthodes. Je me souviens très bien de l'approbation enthousiaste de Willie Fowler (Prix Nobel de physique en 1983) qui, avec ses méthodes de nucléosynthèse, arrivait au même résultat. C'est notre article le plus cité. Je pense que nous devons avoir 500 citations à date pour ce seul travail.

RR: Allons vers un autre sujet : on dit que la multidisciplinarité aujourd'hui est essentielle dans tous les domaines. Est-ce la réalité dans tes recherches ? Par exemple, y a-t-il des méthodes numériques développées ailleurs qui ont pu te servir dans les simulations?

GF: Je vais peut-être te surprendre, René, mais moi je crois que la multidisciplinarité est un sujet un peu galvaudé. Dans mon cas, à part certaines techniques numériques développées par des ingénieurs, je n'ai pas trouvé ailleurs ce qu'il me faut. Au contraire, mais sans généraliser, je me suis plutôt aperçu que dans un domaine qui devient de plus en plus pointu, il faut inventer soi-même ses méthodes et outils numériques. C'est mon expérience personnelle, certes limitée au domaine de l'évolution stellaire. J'ai en tête un de nos vieux professeurs à Laval qui répétait, à qui voulait l'entendre, que la philosophie n'avait rien à amener à la physique...

Je me suis plutôt aperçu que dans un domaine qui devient de plus en plus pointu, il faut inventer soi-même ses méthodes et outils numériques. C'est mon expérience personnelle, certes limitée au domaine de l'évolution stellaire.

RR: Et si on parlait un peu d'enseignement?

GF: D'accord.

RR: Quel est ton enseignement préféré, premier cycle ou les cycles supérieurs?

GF: C'est le premier cycle, parce que j'y rencontre de nouveaux étudiants. Mon cours favori est celui que je dispense en mécanique statistique quantique, à un point tel que je ne prends plus d'année sabbatique depuis environ 17 ans pour ne pas le perdre ! C'est un cours de 3è année que les étudiants apprécient beaucoup. Bon an mal an, de 40 à 50 étudiants s'y inscrivent. Un de mes anciens directeurs a modulé les tâches d'enseignement il y a longtemps et avait comme principe : « Mes meilleurs profs, je les mets au niveau B.Sc., dans les grands groupes. Vous vous arrangez avec le reste ». J'ai donc atterri au B.Sc., mais j'ai eu aussi l'opportunité de créer deux cours aux cycles supérieurs, dont un en astérosismologie, toujours en développement. Ce cours n'est pas offert à chaque année ; il alterne avec un autre. Depuis que j'ai ma Chaire de recherche, ma charge normale est de deux cours par année. Mais, au total, j'ai donné beaucoup de cours durant ma carrière. J'ai commencé par un cours du soir en astronomie populaire. C'était un « show » pour quelque 200 + étudiants hors physique : des optométristes, des médecins, etc. Pas facile de donner un tel cours, un « show » de 3 heures, avec des diapositives !

Mais, j'ai adoré donner ce cours-là, ça marchait bien. En enseignement, je dois dire que j'ai eu pas mal de succès. J'ai eu des prix d'enseignement à tous les niveaux. J'ai fait un arrangement avec mon directeur afin de concentrer mes deux cours au premier trimestre. De janvier à septembre, j'ai plus de temps pour la rencontre des étudiants aux cycles supérieurs, C'est une composante essentielle de ma carrière, échanger avec des jeunes et les conseiller.

RR: Et l'avenir de la carrière ?

GF: Avec le renouvellement de ma chaire de recherche pour un 3è mandat de 7 ans, en principe j'aurai un financement de la CRC jusqu'en 2022. Évidemment, je me croise les doigts pour rester en santé. Ça va super bien. Je ne me vois vraiment pas à la retraite.

RR: Je te remercie beaucoup pour ton temps, Gilles.

GF: C'est moi qui te remercie. Ça m'a fait particulièrement plaisir, René, après toutes ces années-là.

HIGH SCHOOL/CEGEP PHYSICS TEACHING AWARDS / *PRIX ACP EN ENSEIGNEMENT DE LA PHYSIQUE AU SECONDAIRE ET AU COLLÉGIAL*

2016 Winners / Récipiendaires 2016

British Columbia and Yukon /
Colombie-Britannique et Yukon

Favian Yee

North Delta Secondary School
Delta, BC

Quebec et Nunavut /
Québec et Nunavut

Rhys Adams

Cégep Vanier College
Montreal, QC

Prairies and Northwest Territories /
Prairies et Territoires du Nord-Ouest

Jeff Goldie

Strathcona High School
Edmonton, AB

Atlantic / Atlantique

Steve Greer

Charles P. Allen High School
Bedford, NS

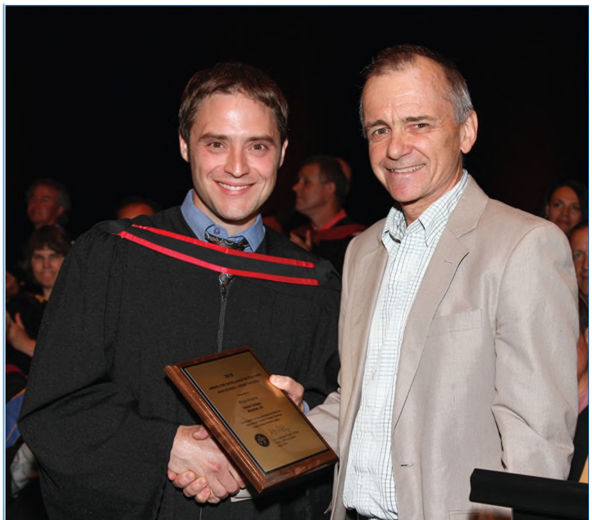
Ontario

Christopher Meyer

York Mills Collegiate Institute
North York, ON

Jeff Goldie was selected to receive the 2016 Perimeter Institute Physics Education Scholarship which includes travel support (provided by Perimeter Institute, the CAP, and the Institute for Particle Physics) to attend a special three-week international workshop for high school teachers hosted by CERN, the world's premier particle physics laboratory located in Geneva and an opportunity to attend the 2017 Perimeter's Einstein Plus camp. J. Goldie's report on the 2016 workshop will be included in Physics in Canada, Volume 72, No. 4 (2016). The remaining winners were offered the opportunity to participate in a one-week research experience at TRIUMF, SNOLAB, or CLS during the Fall of 2016.

Jeff Goldie s'est vu décerner la bourse 2016 de l'Institut Perimètre en enseignement de la physique, comprenant une aide aux déplacements (fournie par l'Institut Perimètre, l'ACP et l'Institut de physique des particules) pour assister à un atelier international spécial de trois semaines pour enseignants au secondaire donné par le CERN, premier laboratoire du monde en physique des particules situé à Genève, et permettant de prendre part au Programme « Einstein Plus » 2017. Le compte rendu de J. Goldie sur l'atelier de 2016 parraitra dans La Physique au Canada, volume 72, no 4 (2016). Les autres lauréats se sont vu offrir l'occasion de participer à une expérience de recherche à TRIUMF, SNOLAB ou au CCRS à l'automne 2016.



On June 21, 2016, Rhys Adams (left) from Cégep Vanier College, Montreal, QC, was presented with the 2016 CAP HS/CEGEP Teaching Award (Québec et Nunavut) at the Théâtre Maisonneuve in Montreal, QC, by Richard MacKenzie, Vice-President of the CAP at the time (right). Mr. Adams received this award for his superb pedagogy of physics at Vanier College and for his leadership in developing an international program to train physics teachers in India and China in active learning pedagogies.

On May 16, 2016, Favian Yee (right) from North Delta Secondary School, Delta, BC, was presented with the 2016 CAP HS/CEGEP Teaching Award (British Columbia and Yukon) at the Canada Wide Science Fair in Montreal, QC, by Richard MacKenzie, Vice-President of the CAP at the time (left). Mr. Yee received this award for his excellence in teaching and his leadership in both the organization of Science Fairs and his encouragement of student participation in the Kwantlen Science Challenge.

On May 13, 2016, Christopher Meyer (right) from York Mills Collegiate Institute, North York, ON, was presented with the 2016 CAP HS/CEGEP Teaching Award (Ontario) at the 2016 May OAPT conference by CAP representative, Richard Taylor (left). Mr. Meyer received this award for his outstanding work in reforming the high school physics curriculum in a manner that has produced demonstrable improvement of student performance over a sustained period.

On June 1, 2016, Jeff Goldie from Strathcona High School in Edmonton, AB, was presented with the 2016 CAP HS/CEGEP Teaching Award (Prairies and Northwest Territories) by CAP representative Kirk Michaelian. Mr. Goldie received this award for his 30-year track record of teaching excellence, his mentorship of other teachers, and his leadership in physics education in Alberta. A report on Mr. Goldie's participation in the 2016 CERN Teachers' Workshop will be published in the *Physics in Canada* Vol. 72, No. 4 issue.

On June 8, 2016, Steve Greer from Charles P. Allen High School, Kelowna, BC, was presented with the 2016 CAP HS/CEGEP Teaching Award (Atlantic) by Adam J. Sarty, President of the CAP at the time. Mr. Greer received this award for his superior ability to bring together the three essential aspects of good teaching: content knowledge, pedagogy and student relationships, and to provide leadership for the Perimeter Institute's Teacher's Network in Atlantic Canada.

PRIZE WINNERS / GAGNANTS DES PRIX

UNIVERSITY PRIZE EXAM RESULTS 2016 - *RÉSULTATS DE L'EXAMEN DU PRIX UNIVERSITAIRE 2016*

This year, 77 students from 14 post-secondary institutions competed in the exam held on February 2nd, 2016, which was run by representatives from the University of Waterloo / *Cette année, 77 étudiants de 14 universités ont participé au concours universitaire qui a eu lieu le 2 février 2016 et qui était administré par l'Université de Waterloo.*

Simon Axelrod	**First Prize / *Premier prix***	Queen's Univ.
Chris Ni	**Second Prize / *Deuxième prix***	Univ. of Toronto
Sam Leutheusser	**Third Prize / *Troisième prix***	Univ. of British Columbia

4.	Theodore Tomalty	McGill Univ.
5.	Chris Prosko	Univ. of Alberta
6.	Aaron Goldberg	McMaster Univ.
7.	Oguzhan Can	Univ. of Toronto
8.	Alan Morningstar	McMaster Univ.
9.	Matthew Quenneville	Simon Fraser Univ.
10.	Ramanjit Sohal	Univ. of Toronto

CAP HIGH SCHOOL PRIZE EXAM - *L'EXAMEN DU SECONDAIRE OU COLLÉGIAL DE L'ACP*
2016 NATIONAL WINNERS - *GAGNANTS 2016 À L'ÉCHELLE NATIONALE*

First Prize / *Premier prix*	Stephen Liu	Bayview S. S.
Second Prize / *Deuxième prix*	Steven Mai	Univ. of Toronto Schools
Third Prize / *Troisième prix*	Jennifer Guo	Marc Garneau C. I.

2016 CANADA-WIDE SCIENCE FAIR - *2016 Expo-sciences pancanadienne*

Nitish Bhatt, Grade 12 student from Gonzaga H.S. in St. John's, Newfoundland receives the CAP prize for best physics project in the senior category from Dr. Richard MacKenzie, Professor at the University of Montreal and President of the CAP.

The 2016 Canada-Wide Science Fair was held from May 15-20 in Montreal, Quebec. This year, the CAP cash award of $1,000 for the best physics project in the senior category was awarded to Nitish Bhatt from Gonzaga H.S. in St. John's, Newfoundland for his project:

L'Expo-sciences pancanadienne de 2016 a eu lieu du 10 au 15 mai à Montréal (Québec). Cette année, le prix de 1000 $ de l'ACP pour le meilleur projet de physique dans la catégorie senior a été attribué à Nitish Bhatt de l'école secondaire Gonzaga à St. John's, Terre-Neuve, pour son projet:

A Computational Approach for Landslide Mitigation and Study

This project develops a Computational Approach for Landslide Mitigation and Study (CALM) which provides analysis of the exposure of human and infrastructure assets to potential precipitation triggered landslide. Using computational experiments, CALM is applied to study regional landslide patterns and determine the effect of spatial and temporal variability of precipitation upon regional landslide risks. Subsequently, CALM is used to study optimal regional landslide mitigation strategies.

Biography: *Nitish Bhatt is a Grade 12 student from Gonzaga High School in St. John's Newfoundland. His inspiration in science comes from his firm belief that knowledge is empowerment. In school, he has taken and enjoyed advanced Physics and Chemistry courses. His studies in science have sparked his interests in exploring the field of physics and systems engineering. He hopes to pursue a career in this field to further his knowledge and understanding of natural systems. In his projects, he has used computational modelling of natural systems to explore natural phenomena; most recently landslides. The boundary where science can be used to help improve lives and livelihoods is his major inspiration. Outside of his activities in science, he also holds community service as an integral activity. He volunteers with local organizations like the Canadian Blood Services and the Association of New Canadians. He is also the founder of an organization called United4Literacy which works to empower children through education and knowledge. Ultimately, he believes that his interests, whether they be science or social justice stem from his passion; and the continual pursuit of passion is the greatest advice he has ever received.*

Join the Fun
Joignez l'amusement

Art of Physics Competition

You are invited to enter the competition (open or high school categories) by capturing in a photograph a beautiful or unusual physics phenomenon and explaining it in less than 200 words in terms that everyone can understand.

The emphasis of this contest is not so much on having a high level of physics comprehension as it is on being able to explain the general principle behind the photograph submitted. Individual (open and high school) and high school class entries are invited up until April 15 each year (see http://www.cap.ca/en/activities/art-physics for entry form and rules). Please note that all entries must be original artwork produced by the participant.

Winning entries will form part of our Art of Physics exhibition which may be on display at the Canada Science and Technology Museum, and may appear as a cover on our publication, *Physics in Canada*. They will also be posted on our Art of Physics website at http://www.cap.ca.

We hope you will take advantage of this opportunity to explore the art of physics by submitting entries for the next competition.

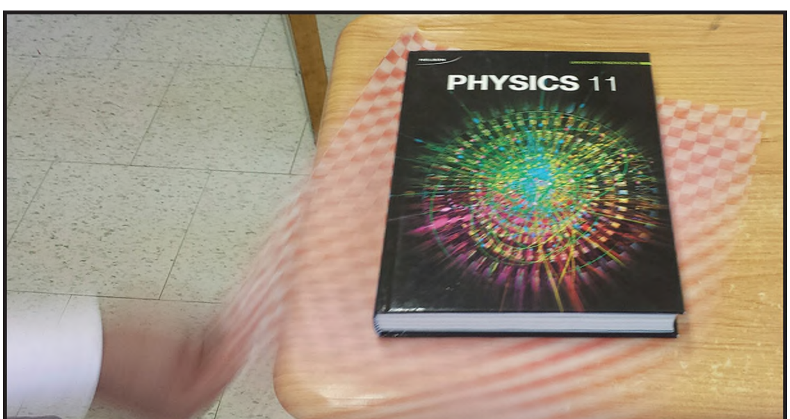
Concours l'Art de la physique

Vous êtes invité(e)s à participer (aux catégories ouverte ou école secondaire) en photographiant un phénomène physique magnifique, ou particulier, et en rédigeant un court texte explicatif de moins de 200 mots, en termes simples et à la portée de tous.

L'accent de ce concours est de pouvoir expliquer le principe général de la photo soumise plutôt que de démontrer un niveau élevé de compréhension de la physique. L'échéance pour les inscriptions individuelles (ouvert et école secondaire) et scolaires (voir formulaire d'inscription/règlements à http://www.cap.ca/fr/activites/lart-de-hysique) est fixée au 15 avril chaque année. Notez bien que toutes les inscriptions doivent être des oeuvres originales du participant ou de la participante.

Les soumissions gagnantes feront partie de notre exposition L'Art de la physique au Musée des sciences et de la technologie du Canada et auront une chance de paraître sur la couverture d'un numéro de *La Physique au Canada*. Elles seront également affichées sous la rubrique L'Art de la physique du site web de l'ACP à l'adresse suivante: http://www.cap.ca.

Nous espérons que vous profiterez de cette occasion d'explorer l'art de la physique en soumettant une oeuvre pour la prochaine compétition.



"Inertia in Real Life"
Honourable Mention - 2015 Competition High School Individual Category

by Mohammed Emin Yilmaz, Nile Academy, Toronto, ON

http://www.cap.ca/aop/aop/2015-inertia.html

2015 CAP FOUNDATION BOARD OF DIRECTORS' ANNUAL REPORT

ABOUT THE CAP FOUNDATION

The CAP Foundation (CAPF) is a registered charity[1] administered by a Board of Directors elected by the CAP Board. Income from donors and corporate sponsors, supplemented by targeted fundraising campaigns, is allocated to key activities in education and outreach undertaken in support of Canadian physics.

Board of Directors for June 2015–June 2016

(*bios of the Board of Directors can be found on the CAPF website at http://www.cap.ca/en/capf*)

J. Michael Roney, P.Phys.
University of Victoria
(Chair)

Michael R. Morrow
Memorial University
(Vice-Chair)

Brigitte Vachon
McGill University
(Secretary)

Other Directors

LeeAnn Janissen
Ceramic Artist, Toronto

Sinan Akdeniz
President,
East Coast Fund Management Inc.,
Toronto

Peter Calamai
Communications Consultant,
Freelance Writer, and Editor,
Ottawa

The CAPF Treasurer is David Lockwood from NRC; the Executive Manager is Francine Ford from the CAP.

EXECUTIVE SUMMARY

In 2015, its second full year of operation, the CAP Foundation Board worked toward the development of a strategy for the launch of its first major fundraising campaign. It was a year of tremendous excitement and activity for the Board but also one that brought many challenges as the Board worked to understand how best to present its case to members and potential donors and to understand its role in the development and delivery of educational initiatives consistent with the CAP's strategic plan. It was a year that again saw some changes in Board membership.

Leah Eustace, of GoodWorks, led a 1-day Board retreat in March 2015 the purpose of which was, in part, to identify groups to whom CAPF-sponsored activities are relevant. This led to GoodWorks being contracted to develop a Case for Support. In the course of doing so, GoodWorks interviewed key individuals to identify themes that could resonate with potential donors.

After its meeting at the 2015 CAP Congress in Edmonton, the Board met at least once a month via teleconference for most of 2015. The frequency of meetings increased in the last few months of 2015 in anticipation of the fundraising campaign launch.

One of the most exciting developments of 2015 was an invitation, from Dr. Alan Carswell, to submit a proposal to the Carswell Family Foundation for matching funding support of new CAPF initiatives. This opportunity was a focus of Board activity during the last two months of 2015 and early parts of 2016 which ultimately led to a matching fund campaign in 2016 which will be highlighted in the 2016 CAPF Annual Report.

We are grateful to the many donors who made commitments, in 2015, to support the educational activities of the CAPF. The activities supported by the CAPF are only possible because of the substantial contributions of time and effort by individual CAP members, the CAP Board, and CAP staff members and the CAPF Board is deeply grateful for those contributions. The activities supported by the CAPF inspire students and educators to pursue excellence in physics teaching, learning and discovery. Students and educators alike are inspired and encouraged by the activities of the CAPF to reach high goals in the research, teaching, and learning of physics in Canada. Ultimately, the objective of the CAPF is to contribute to Canada's capacity to meet future challenges by animating the next generation of physicists.

1. Charitable Registration #122067572RC0001

2015 ACTIVITIES

The CAPF is the oversight body for major activities in education and outreach in physics that are consistent with the general mandate of the CAP. These activities are supported and administered by the CAPF, assisted by targeted fundraising efforts and a contribution from the CAP General Fund. A summary of the significant activities for 2015 follows.

Stoicheff Scholarship

Established in 2012 in memory of Dr. Boris Stoicheff, this award is given annually to an outstanding graduate student demonstrating both research excellence and significant service to the optics or physics community. The 2015 scholarship was administered by the Optical Society of America Foundation and was awarded to Itai Epstein of Tel-Aviv University.

Undergraduate Lecture Tour

The national Undergraduate Lecture Tour is the largest program under the aegis of the CAPF. Costs are shared with participating Physics Departments, with additional funds to support this event raised each year in collaboration with industrial sponsors and government as appropriate. The 2015 tour consisted of lectures given by 15 different speakers in 50 physics department in Canada (see http://www.cap.ca/en/students-educators/cap-lecture-tour/2015-lecture-tour/2015-lecture-tour-schedule for details).

Prizes and Awards

In 2015, the Annual CAP prize exam competitions were held at both the high school and university level. For the High School Prize Exam, the prizes ($500, $300, and $200 respectively) for the top three national results were awarded to students from Ontario and Manitoba. In addition, the CAPF awarded three prizes ($250, $150, and $100 respectively) for the top three results in each of the 10 provinces, one of which (Newfoundland) had two students sharing third. In 2015, the CAP Lloyd G. Elliot University Prize Exam was written by 65 students from 17 universities. In 2015, the winner of the 1st prize in this competition was Chao Wang, University of Toronto. Three students were tied for 2nd in this competition: Sean Rideout, McMaster University, Étienne Lantagne-Hurtubise, Université de Montréal, and Simon Blouin, Université de Montréal. Full details for both the high school and university-level prizes can be obtained at http://www.cap.ca/en/activities/medals-and-awards/prize-students.

The **CAP Award for Excellence in Teaching High School/CÉGEP Physics** was introduced in 2010. The award continues to gain recognition in high schools and CEGEPs across Canada. It is currently sponsored at the national level by the CAP, TRIUMF, Perimeter Institute, and Nelson Education, and at the regional level by the Association of Professional Engineers and Geoscientists of BC and includes a grant and an invitation to participate in one of five training opportunities described below. The selection committee was chaired by Robert Mann of the University of Waterloo, and consisted of 3 past winners of the award (Peter Vogel, Roberta Tevlin, and Brian Dentry) along with Daria Ahrensmeier, Simon Fraser University, Donald Mathewson, Kwantlen University College, British Columbia, and Patricia Mitchler, Kelvin High School, Manitoba.

In 2015, the four outstanding teachers from across Canada that received this award were:

Raynald Richer, CÉGEP de Chicoutimi for Quebec and Nunavut
James Ball, J. F. Ross CVI for Ontario
Patrick Kossmann, Greenall High School for the Prairies and Northwest Territories
James Strachan, Kelowna Secondary School for British Columbia and Yukon

James Strachan was selected to receive the 2015 Perimeter Institute Physics Education Scholarship which includes travel support (provided by Perimeter Institute, CAP, and the Institute for Particle Physics) to attend a special three-week international workshop for high school teachers hosted by CERN, the world's premier particle physics laboratory located in Geneva and an opportunity to attend the 2017 Perimeter's Einstein Plus camp. J. Strachan's report on the 2015 workshop was included in *Physics in Canada*, Volume 71, No. 4 (2015). The remaining winners were offered the opportunity to participate in a one-week research experience at TRIUMF, SNOLAB, or the CLS during the Fall of 2015. James Ball was hosted by TRIUMF, Patrick Kossman by SNOLAB, and Raynald Richer by the CLS.

Conference Support

The 51st Canadian Undergraduate Physics Conference (CUPC) was held at Trent University in October 2015 with over 200 attendees. There were 114 student talks and 30 student posters. Keynote talks were given by James Fraser, Patricia Burchat, Paul Torrey, and Paul Corkum. There were 37 booths at the Graduate and Career Fair. The CAPF provided financial support to assist student participants attending the conference. A report on this conference, written by the 2015 CUPC Chair James Godfrey, was published in *Physics in Canada*, Vol. 72, No. 1 (2016). The 52nd conference will be held at Dalhousie University in October 2016.

In September 2015, the biennial Canada-America-Mexico Graduate Student Conference was held in Oaxaca, Mexico. The Canadian delegation included 10 graduate student participants and three invited plenary speakers (Kristen Poduska, Pablo Bianucci, and Michael Steinitz). A report on this conference, written by the CAP's graduate student representative on the international organizing committee, Christopher Pugh from the University of Waterloo, appeared in *Physics in Canada*, Vol. 71, No. 4 (2015).

CAPF FINANCES

For the 2015 Calendar year, expenses for the CAPF exceeded revenues by $16,211. Relative to 2014, total expenses increased by $6,080. In part, this reflects changes in support for the CAM Graduate Student Conference, which was provided in 2015 but not 2014, and for the Stoicheff Graduate Scholarship, which was provided in 2014 but not 2015. In addition, expenses associated with the CAP Lecture Tour decreased by about $5,800 from 2014 to 2015 but administrative and other expenses increased by about $6.800. The latter increase reflects expenses (a one-day CAPF Board retreat to discuss CAPF-sponsored activities and the

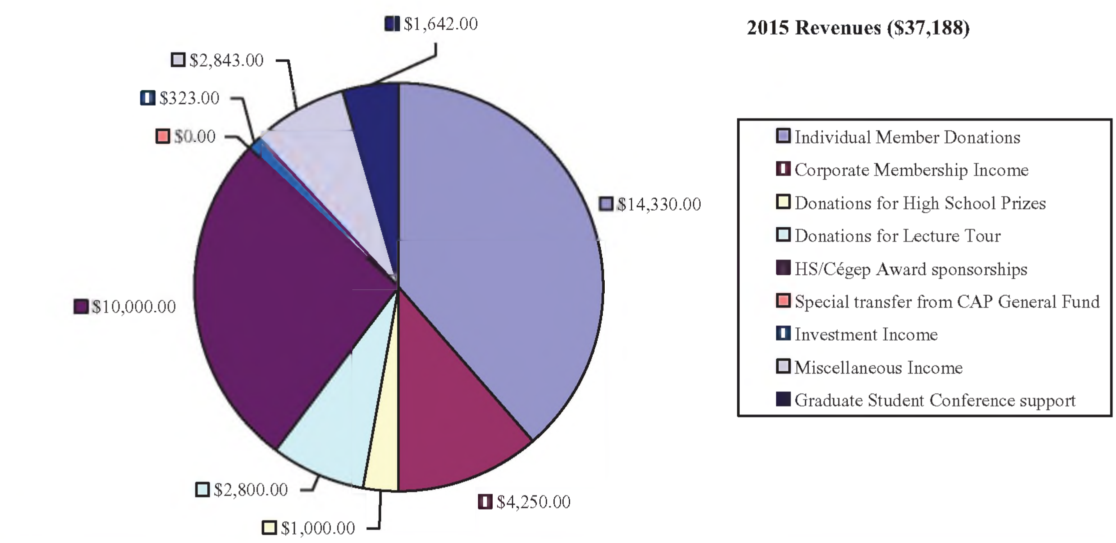


Fig. 1 Sources of revenue to the CAPF in 2015, based on audited statements.

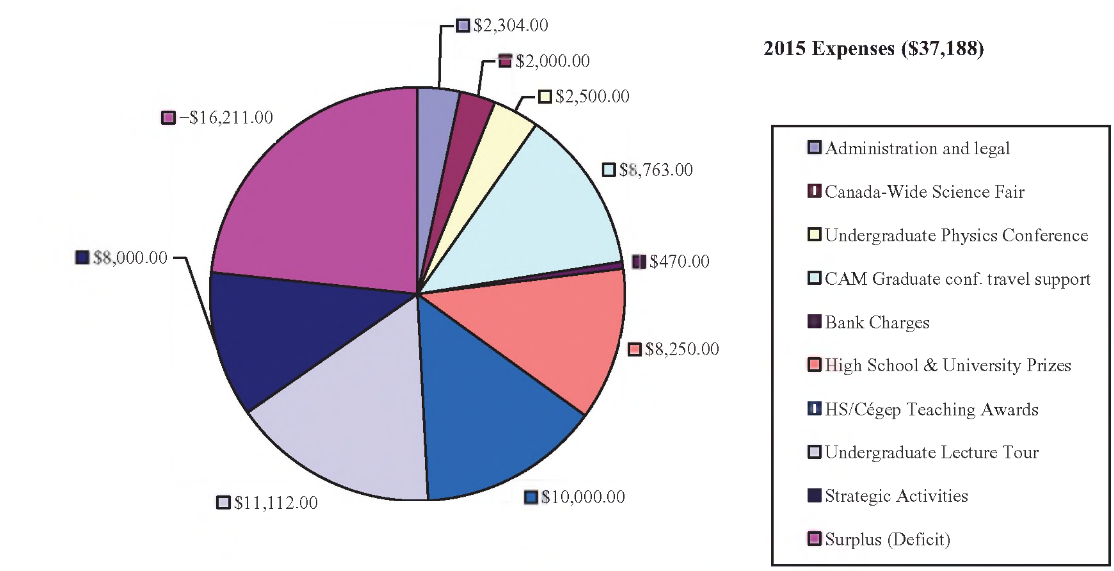


Fig. 2 Expenditures from the CAPF in 2015, based on audited statements.

preparation, by GoodWorks, of a case for support) associated with preparations for the 2016 launch of the Ignite the Spark fundraising campaign. The decrease in revenues reflects a decline of about $5000 in member donations from 2014 to 2015 and a significant decline, from over $6,800 in 2014 to about $300 in 2015, in investment income. The grant to the CAPF from the CAP ($4250 for Corporate Memberships and $2000 for the Lecture tour) was unchanged from 2014. The change from a significant surplus situation in 2013 to a small deficit in 2014 was noted, in the 2014 CAPF Annual Report, as a disturbing trend that needed to be reversed. This trend, unfortunately, did continue into 2015 but it is anticipated that the CAPF Ignite the Spark fundraising campaign, which was launched just prior to the 2016 CAP Congress, will significantly alter this trend. As noted in the 2014 CAPF report, the Foundation cannot rely primarily on CAP revenues to sponsor its activities and this realization is reflected in the Board's effort to develop a strong case for the fundraising campaign being launched in 2016.

CAPF STRATEGIC ACTIVITIES IN 2015

The 2014 Annual Report included an update on strategic activities to July 2015. As noted in that update, Leah Eustace, of GoodWorks, led a 1-day Board retreat in March 2015 to, in part, identify groups to whom CAPF-sponsored activities are relevant. This led to the approval, by the CAPF Board, of a proposal, from GoodWorks Communications Inc., to develop a Case for Support. A Letter of Agreement for the development of a Case for Support was signed with GoodWorks in May 2015. As part of that development work, GoodWorks interviewed some key individuals to identify themes that might resonate with potential donors. These interviews were conducted in August and September of 2015. A draft of the Case for Support was provided in October 2015 and the Case for Support document was finalized later that month. This document will be used as a source for the development of documentation in support of anticipated fundraising campaigns.

In early October, 2015, the CAPF Board Chair and Vice-chair participated, by teleconference, in a strategy meeting of the CAP Board. Interactions like this are an important way to ensure that the activities of the CAPF remain closely aligned with the strategic objectives of the CAP and with the CAP's evolving communications strategy.

At the end of October, the CAPF Board received a remarkable invitation, from Dr. Alan Carswell, a former Past President of the CAP who was interviewed by GoodWorks as part of the development of the CAPF Case for Support, to submit a proposal to the Carswell Family Foundation for funds to be used by the CAPF in support of its educational activities. This opportunity was a focus of Board activity during the last two months of 2015 and early parts of 2016. As noted in the update below, this led to a generous contribution, in the form of matching funds, that was leveraged in the launch of the Ignite the Spark campaign just before the 2016 CAP Congress.

CONCLUSION AND OUTLOOK

For the CAPF, 2015 was an exciting and a challenging year. It continued to support a core of activities – the University and High School Prize exams, the High School/CEGEP teaching awards, the undergraduate lecture tour, and the graduate student awards – that encourage and promote physics in Canada. Doing so with a relatively static base of donor support was a challenge, but this challenge also inspired efforts to develop a new and ambitious approach to fundraising for physics educational activities in Canada.

During 2015, the CAPF Board focused considerable attention on plans to transform the scope of initiatives it delivers, in response to the needs of the recent CAP Strategic Plan, and to develop a strategy to raise the funds necessary to support those initiatives. The CAPF Board identified exciting opportunities and identified significant challenges. It remains committed to meeting those challenges so that, with the support of CAP members and donors, it can encourage new opportunities to animate the next generation of Canadian physicists.

The CAPF Board wishes to conclude this report by expressing its deep and sincere thanks to the many individual donors and corporate / institutional sponsors who have contributed to the support of so many important education and outreach activities in 2015. As the CAPF launches its Ignite the Spark campaign in 2016, we hope that you will take the opportunity to consider the new initiatives that we are proposing to pursue and that you will be encouraged to respond accordingly.

CAPF STRATEGIC ACTIVITIES – UPDATE TO JULY 2016

Given the timing of this report's preparation, the CAPF Board is taking this opportunity to include the following short update on activities to July 2016.

A final version of the CAPF Case for Support was approved by the CAPF Board at the end of 2015. This document has been, and will continue to be, used as a source for material developed in support of anticipated fundraising efforts.

With the help of feedback from Dr. Carswell, the CAPF Board refined its proposal to the Carswell Family Foundation (CFF) and, in March 2016, the CAPF and

CFF entered into an agreement whereby the CFF would match any funding raised by the CAPF over the coming year above the 2015 level, with a goal of reaching total new funding of $50k. Brochures and letters announcing the CAPF Ignite the Spark campaign were prepared and messages to potential sponsors and CAP members were sent out in May 2016. The formal launch of the campaign was scheduled to coincide with the 2016 CAP Congress in Ottawa. Donors committing to a specified contribution prior to Congress were recognized as charter donors in the program for the 2016 CAP Recognition Gala held at the Shaw Centre in Ottawa. One of the highlights was a pre-Gala reception, for charter donors and CAP award winners, attended by His Excellency the Right Honourable David Johnston, Governor General of Canada, Dr. Art McDonald, winner of the 2015 Nobel Prize for Physics, and Dr. Alan Carswell of the Carswell Family Foundation.

Two CAPF Board members, Michael Roney (Chair) and Brigitte Vachon (Secretary) completed their terms in June 2016. Michael Roney agreed to be reappointed (two-year term) and Gabor Kunstatter, a CAP past President from the University of Winnipeg, agreed to stand for a three-year term. Their appointments were approved at a June 6, 2016 meeting of the CAPF membership. The CAPF Board continues to search for members, particularly from outside the academic environment, who can contribute to the breadth, balance, and skill set of the Board. Full bios of all current CAPF Board members can be found at http://www.cap.ca/en/CAPF/Directors.

"THANK YOU" TO OUR 2015 DONORS AND SPONSORS

Please note that the list of donors below DOES NOT include individual and corporate donors to the 2016 CAPF "Ignite the Spark" campaign. These individuals will be listed in the 2016 Annual Report which will be published in the first quarter of 2017.

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TRIUMF, Perimeter Institute, Nelson Education, and Association of Professional Engineers and Geoscientists of British Columbia

Sponsors - 2015 Perimeter Institute Physics Education Scholarship, In Partnership With CAP And IPP

(Recipient was James Strachan from Kelowna Secondary School in Kelowna, BC)

CAP, Perimeter Institute and Institute for Particle Physics

We remind our readers that donations to the 2016 CAPF "Ignite the Spark" campaign are tax deductible. Donations made during 2016 which are above the level obtained in 2015 are being generously matched by the Carswell Family Foundation. We have an ambitious goal of $50,000; as at July 2016 50% of the goal has been reached. Contributions may be made by anyone, at any time, via the secure online form at: https://www.cap.ca/donate/, or during the annual membership renewal. Tax receipts will be issued for donations of $10 or more.

Rapport annuel 2015 du conseil d'administration de la fondation de l'ACP

À PROPOS DE LA FONDATION DE L'ACP

La Fondation de l'ACP (FACP) est un organisme de bienfaisance enregistré[1], administré par un conseil d'administration élu par le Conseil de l'ACP. Les fonds provenant de donateurs et d'entreprises partenaires, plus ceux de campagnes de souscription ciblées, servent à financer les principales activités d'éducation et de sensibilisation menées à l'appui de la physique au Canada.

Conseil d'administration, juin 2015-juin 2016
(*les notices biographiques des membres du Conseil d'administration figurent au site Web de la FACP, à http://www.cap.ca/fr/FACP*)

J. Michael Roney, Phys.
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Peter Calamai
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Le trésorier de la FACP est David Lockwood du CNRC; la dirigeante est Francine Ford de l'ACP.

Résumé

En 2015, à sa deuxième année complète de fonctionnement, le Conseil de la Fondation de l'ACP s'est employé à élaborer une stratégie pour le lancement de sa première grande campagne de souscription. Pour lui, ce fut une année remplie d'activités palpitantes, mais aussi de défis, alors qu'il cherchait le meilleur moyen d'exposer son projet aux membres et aux donateurs éventuels et de saisir son rôle dans l'élaboration et la réalisation d'initiatives éducatives qui soient conformes au plan stratégique de l'ACP. Ce fut une année où l'effectif du Conseil a de nouveau subi des changements.

Leah Eustace, de GoodWorks, a dirigé pour le Conseil en mars 2015, une journée de réflexion qui visait en partie à trouver les groupes concernés par les activités parrainées par la FACP. Cela a donné lieu à l'attribution à GoodWorks d'un contrat d'élaboration de la quête d'appuis. Dans l'exécution de ce contrat, GoodWorks a interviewé des personnes clés afin de déterminer les thèmes susceptibles de plaire aux donateurs éventuels.

Après la réunion tenue au congrès 2015 de l'ACP à Edmonton, le Conseil a eu au moins une téléconférence presque tous les mois en 2015, augmentant la fréquence des réunions au cours des derniers mois en prévision du lancement de la campagne de souscription.

L'un des faits les plus fabuleux de 2015 a été l'invitation du D^{r} Alan Carswell à proposer à la fondation Carswell Family Foundation d'offrir un financement de contrepartie pour les nouvelles initiatives de la FACP. Le Conseil a axé ses activités sur cette possibilité au cours des deux derniers mois de 2015 et au début de 2016, ce qui a finalement débouché sur une campagne de financement de contrepartie en 2016, qui sera soulignée dans le Rapport annuel 2016 de la FACP.

Nous sommes reconnaissants aux donateurs qui se sont engagés, en 2015, à soutenir les activités éducatives de la FACP. Les activités qu'elle finance ne sont possibles que grâce au temps et aux efforts offerts généreusement par les membres de l'ACP, le Conseil de l'ACP et les membres du personnel de l'ACP, et le Conseil de la FACP les remercie vivement de ces efforts. Les activités financées par la FACP incitent les étudiants et les enseignants à poursuivre l'excellence dans l'enseignement, l'apprentissage et la découverte de la physique. Les activités de la FACP inspirent étudiants et enseignants et les encouragent à atteindre ces objectifs élevés dans la recherche, l'enseignement et l'apprentissage de la physique au Canada. En bout de ligne, l'objectif de la FACP est d'accroître la capacité du Canada à relever les défis futurs en inspirant la prochaine génération de physiciens.

1. **Numéro d'enregistrement 122067572RC0001**

ACTIVITÉS DE 2015

La FACP est l'organisme qui surveille les grandes activités d'enseignement et de sensibilisation à la physique qui sont conformes au mandat général de l'ACP. Elle finance et administre ces activités, secondée par des collectes de fonds ciblées et une ponction au fonds général de l'ACP. Voici un résumé des activités importantes pour 2015.

Bourse Stoicheff : Créé en 2012 en mémoire du D[r] Boris Stoicheff, ce prix est remis chaque année à un étudiant talentueux d'un cycle supérieur, qui a fait preuve d'excellence en recherche et d'un service important à la collectivité de l'optique ou de la physique. La bourse de 2015, administrée par l'Optical Society of America Foundation, a été décernée à Itai Epstein de l'Université de Tel-Aviv.

Tournée de conférenciers pour étudiants en physique : La Tournée nationale de conférenciers pour étudiants en physique est le programme le plus important qui relève de la FACP. Les coûts en sont répartis entre les départements de physique participants et l'on recueille des fonds supplémentaires chaque année, en collaboration avec les partenaires de l'industrie et du gouvernement selon le cas, pour financer cette activité. La tournée de 2015 comportait des conférences données par 15 conférenciers différents dans 50 départements de physique au Canada (voir en détail à http://www.cap.ca/fr/etudiants-enseignants/tournee-des-conferenciers-lacp/tournee-2015/programme-tournee-2015).

Prix

En 2015, l'ACP a tenu des examens annuels aux niveaux secondaire et universitaire. Pour les examens annuels au niveau secondaire, les prix (500 $, 300 $ et 200 $, respectivement) décernés aux trois meilleures notes au niveau national sont allés à des étudiants de l'Ontario et du Manitoba. De plus, la FACP a remis trois prix (250 $, 150 $ et 100 $, respectivement) pour les trois meilleures notes dans chacune des dix provinces, dont une (Terre-Neuve) comptait deux étudiants ayant la même note. En 2015, 65 étudiants de 17 universités ont subi l'examen Lloyd G. Elliot de l'ACP. En 2015, le lauréat du 1[er] prix de ce concours a été Chao Wang, Université de Toronto. Trois étudiants sont arrivés ex aequo au 2[e] prix du concours: Sean Rideout, Université McMaster, Étienne Lantagne-Hurtubise, Université de Montréal, et Simon Blouin, Université de Montréal. Tous les détails pour les prix de niveaux secondaire et universitaire figurent à http://www.cap.ca/fr/activites/medailles-bourses/prix-etudiants.

Le **Prix d'excellence de l'ACP en enseignement de la physique au secondaire et au collégial** a été créé en 2010. Il a une notoriété de plus en plus grande dans les écoles secondaires et cégeps de tout le Canada. Ce prix est actuellement parrainé au niveau national par l'ACP, TRIUMF, l'Institut Perimeter et Nelson Education, et au niveau régional par l'Association of Professional Engineers and Geoscientists of BC. Il comprend une subvention et une invitation à profiter de l'une des cinq occasions de formation décrites ci-après. Le comité de sélection était présidé par Robert Mann de l'Université de Waterloo et composé de trois anciens lauréats du prix (Peter Vogel, Roberta Tevlin et Brian Dentry) ainsi que de Daria Ahrensmeier, Université Simon Fraser, Donald Mathewson, Kwantlen University College, Colombie-Britannique, et Patricia Mitchler, École secondaire Kelvin, Manitoba.

En 2015, voici les quatre enseignants exceptionnels de l'ensemble du Canada à avoir reçu ce prix :

Raynald Richer, CÉGEP de Chicoutimi, pour le Québec et le Nunavut
James Ball, J. F. Ross CVI, pour l'Ontario
Patrick Kossmann, École secondaire Greenall, pour les Prairies et les Territoires du Nord-Ouest
James Strachan, École secondaire de Kelowna, pour la Colombie-Britannique et Yukon

James Strachan s'est vu décerner la bourse 2015 de l'Institut Perimeter en enseignement de la physique, comprenant une aide aux déplacements (fournie par l'Institut Perimeter, l'ACP et l'Institut de physique des particules) pour assister à un atelier international spécial de trois semaines pour enseignants au secondaire donné par le CERN, premier laboratoire du monde en physique des particules situé à Genève, et permettant de prendre part au Programme « Einstein Plus » 2017. Le compte rendu de J. Strachan sur l'atelier de 2015 a paru dans *La Physique au Canada, volume* 71, n[o] 4 (2015). Les autres lauréats se sont vu offrir l'occasion de participer à une expérience de recherche à TRIUMF, SNOLAB ou au CCRS à l'automne 2015. James Ball a été reçu par TRIUMF, Patrick Kossman par SNOLAB et Raynald Richer par le CCRS.

Soutien à la Conférence : La 51[e] Conférence canadienne des étudiants de physique (CCEP) s'est tenue à l'Université Trent en octobre 2015 et comptait plus de 200 participants, ainsi que 114 allocutions et 30 affiches d'étudiants. Les principales allocutions ont été prononcées par James Fraser, Patricia Burchat, Paul Torrey et Paul Corkum. Le salon des diplômés et des carrières comptait 37 kiosques. La FACP a fourni une aide financière aux étudiants participant à la conférence, dont le compte rendu, rédigé par James Godfrey, président de la CCEP 2015, est paru dans *La Physique au Canada, volume* 72, n[o] 1 (2016). La 52[e] conférence se tiendra à l'Université Dalhousie en octobre 2016.

En septembre 2015, la Conférence biennale d'étudiants diplômés de physique Canada-États-Unis-Mexique a eu lieu à Oaxaca, au Mexique. La délégation canadienne comprenait dix étudiants participants de cycles supérieurs et trois conférenciers invités aux séances plénières

(Kristen Poduska, Pablo Bianucci et Michael Steinitz). Le compte rendu de cette conférence, rédigé par le représentant de l'ACP pour les étudiants de cycles supérieurs auprès du comité organisateur international, Christopher Pugh de l'Université de Waterloo, figure dans *La Physique au Canada, volume* 71, n° 4 (2015).

Finances de la FACP

Pour l'année civile 2015, les dépenses de la FACP dépassent ses recettes de 16 211 $. Par rapport à 2014, les dépenses totales ont augmenté de 6 080 $. Cela reflète en partie les changements au financement de la Conférence d'étudiants diplômés (CAM), fourni en 2015 mais pas en 2014, et de la Bourse Stoicheff pour étudiants de cycles supérieurs, fournie en 2014 mais pas en 2015. En outre, les dépenses liées à la Tournée de conférenciers de l'ACP ont diminué d'environ 5 800 $ de 2014 à 2015, mais les frais d'administration et les autres dépenses ont augmenté d'environ 6 800 $. Cette dernière hausse tient compte des dépenses (journée de réflexion du Conseil de la FACP

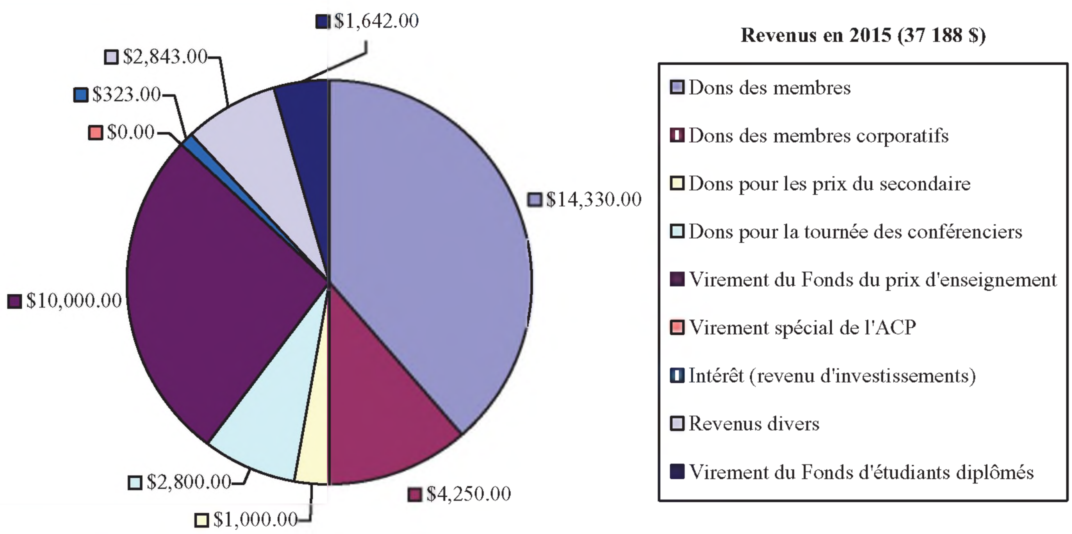

Fig. 1 Revenus de la FACP en 2015, selon les états financiers vérifiés.

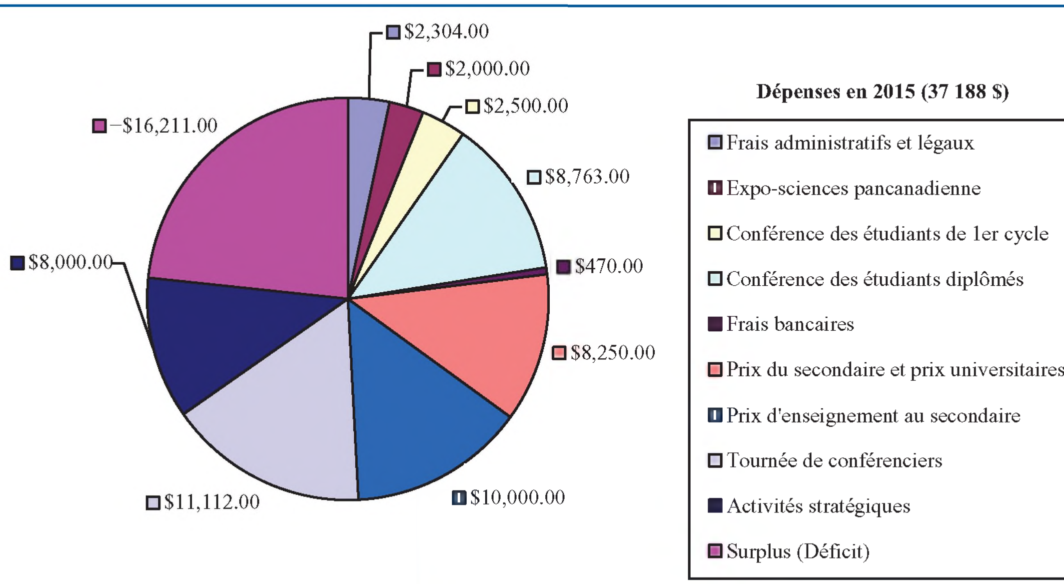

Fig. 2 Dépenses de la FACP en 2015, selon les états financiers vérifiés

pour examiner les activités parrainées par elle et la préparation, par GoodWorks, du document de quête d'appuis) liées aux préparatifs du lancement de la campagne de souscription « Allumer la flamme », en 2016. La baisse des recettes traduit une diminution d'environ 5000 $ des dons de membres de 2014 à 2015 et une forte chute des revenus de placement (de plus de 6 800 $ en 2014 à environ 300 $ en 2015). La subvention de l'ACP à la FACP (4250 $ pour les membres corporatifs et 2000 $ pour la Tournée de conférenciers) est demeurée inchangée par rapport à 2014. Le Rapport annuel 2014 de la FACP fait état du passage d'un important excédent en 2013 à un faible déficit en 2014, qualifiant la chose de tendance alarmante devant être inversée. Cette tendance s'est malheureusement poursuivie en 2015 mais on prévoit que la campagne de financement « Allumer la flamme », de la FACP, lancée juste avant le congrès 2016 de l'ACP, l'infléchira sensiblement. Comme on peut le lire dans le rapport 2014 de la FACP, la Fondation ne peut compter principalement sur les recettes de l'ACP pour financer ses activités et cette constatation se traduit dans les efforts du Conseil pour faire valoir avec force la nécessité de lancer une campagne de souscription en 2016.

Activités stratégiques de la FACP en 2015

Le Rapport annuel 2014 fait le point sur les activités stratégiques, au mois de juillet 2015. Comme on y voit, Leah Eustace, de GoodWorks, a dirigé en mars 2015 pour le Conseil, une journée de réflexion visant en partie à trouver les groupes que concernent les activités parrainées par la FACP. Cela a amené le Conseil de la FACP à approuver une proposition de GoodWorks Communications Inc., visant à élaborer une quête d'appuis. GoodWorks a signé en mai 2015 une lettre d'entente pour l'élaboration du document. Dans le cadre de ce travail, GoodWorks a interviewé des personnes clés afin de déterminer les thèmes susceptibles de plaire aux donateurs éventuels. Ces entrevues ont eu lieu en août et septembre 2015. Une ébauche de ce document a été présentée en octobre 2015 et finalisée à la fin de ce mois-là. Elle servira à élaborer les documents destinés aux campagnes de souscription prévues.

Au début d'octobre 2015, les président et vice-président du Conseil de la FACP ont participé à une réunion stratégique du Conseil de l'ACP tenue par téléconférence. De telles interactions sont un moyen important d'assurer que les activités de la FACP demeurent étroitement conformes aux objectifs stratégiques de l'ACP et à la stratégie de communication de l'ACP, qui évolue.

À la fin d'octobre, le Conseil de la FACP a reçu une invitation notoire du D^r^ Alan Carswell, l'ancien président de l'ACP que GoodWorks a interviewé lors de l'élaboration de la quête d'appuis à la FACP, à présenter une proposition à la fondation Carswell Family Foundation en vue d'obtenir pour la FACP des fonds destinés à ses activités éducatives. Le Conseil a axé son action sur cette possibilité au cours des deux derniers mois de 2015 et au début de 2016. Comme on peut le lire dans le résumé qui suit, cela a débouché sur une généreuse contribution, sous forme d'un financement de contrepartie procuré par la campagne « Allumer la flamme », lancée juste avant le congrès 2016 de l'ACP.

Conclusion et perspectives

Pour la FACP, 2015 a été une année emballante et stimulante. Elle a permis de soutenir une foule d'activités – examens aux niveaux universitaire et secondaire, prix en enseignement au secondaire et dans les cégeps, tournée de conférenciers pour étudiants en physique et prix aux étudiants diplômés – qui encouragent et favorisent la physique au Canada. Y parvenir grâce au soutien d'un bassin de donateurs relativement stable a été un défi qui a toutefois su inspirer les efforts pour instaurer une méthode nouvelle et ambitieuse de recueillir des fonds destinés aux activités éducatives en physique au Canada.

En 2015, le Conseil de la FACP a porté une grande attention aux plans visant à rehausser l'ampleur des initiatives qu'il réalise, face aux besoins du dernier plan stratégique de l'ACP, et à élaborer une stratégie de collecte des fonds requis pour financer ces initiatives. Le Conseil a relevé d'excitantes possibilités et d'importants défis. Il demeure déterminé à relever ces défis, avec l'appui des membres de l'ACP et des donateurs, afin de pouvoir encourager de nouvelles possibilités, capables d'inspirer la prochaine génération de physiciens canadiens.

Le Conseil de la FACP souhaite conclure le présent rapport en remerciant de façon sincère et profonde les nombreux donateurs et établissements/sociétés partenaires qui ont contribué à soutenir les si nombreuses et importantes activités d'éducation et de sensibilisation menées en 2015. Au moment où la FACP lance sa campagne « Allumer la flamme » en 2016, nous espérons que vous profiterez de l'occasion pour examiner les initiatives nouvelles que nous nous proposons de réaliser et que vous en serez incité à réagir en conséquence.

Activités stratégiques de la FACP – mises à jour, au mois de juillet 2016

Vu le moment où le présent rapport est rédigé, le Conseil de la FACP profite de l'occasion pour ajouter la brève mise à jour suivante, au mois de juillet 2016.

Le Conseil de la FACP a approuvé la version finale du document de quête d'appuis de la FACP à la fin de 2015. Ce document a été et demeurera une source dont sera tirée la documentation servant à appuyer les collectes de fonds prévues.

La rétroaction du D^r^ Carswell a permis au Conseil de la FACP de peaufiner sa proposition à la fondation

Carswell Family Foundation (CFF) et, en mars 2016, la FACP et la CFF ont conclu une entente amenant la CFF à offrir la contrepartie de tous les fonds que recueillera la FACP durant la prochaine année, au-delà du niveau de 2015, dans le but d'atteindre un nouveau fonds global de 50 000 $. Les brochures et lettres annonçant la campagne de la FACP « Allumer la flamme » sont prêtes et les messages aux partenaires éventuels et aux membres de l'ACP ont été envoyés en mai 2016. Le lancement officiel de la campagne a été prévu de manière à coïncider avec le congrès 2016 de l'ACP à Ottawa. Les donateurs qui s'étaient engagés à verser un montant précis avant le congrès ont été reconnus à titre de donateurs fondateurs au Gala de reconnaissance 2016 de l'ACP, au Centre Shaw, à Ottawa. L'un des points marquants a été la réception donnée pour eux et pour les lauréats de prix de l'ACP avant le Gala, où l'on retrouvait Son Excellence le Très Honorable David Johnston, Gouverneur général du Canada, le Dr Art McDonald, lauréat du prix Nobel 2015 de physique, et le Dr Alan Carswell de la fondation Carswell Family Foundation.

Deux membres du Conseil de la FACP, Michael Roney (président) et Brigitte Vachon (secrétaire), ont terminé leurs mandats en juin 2016. Michael Roney a accepté une nouvelle nomination (mandat de deux ans) et Gabor Kunstatter, ancien président de l'ACP de l'Université de Winnipeg, a accepté un mandat de trois ans. Leurs nominations ont été approuvées à la réunion tenue le 6 juin 2016 par les membres de la FACP. Le Conseil de la FACP poursuit sa recherche de membres, notamment hors du milieu universitaire, ce qui peut contribuer à accroître l'étendue, l'équilibre et l'ensemble de ses compétences. Les notices biographiques complètes de tous les membres actuels du Conseil de la FACP figurent à http://www.cap.ca/fr/FACP/directeurs.

« *MERCI* » *À NOS DONATEURS ET COMMANDITAIRES EN 2015*

Veuillez noter que la liste des donateurs N'INCLUE PAS les membres individuels et les membres corporatifs qui ont fait un don à la campagne 2016 de la Fondation « Allumer la flamme ». La liste de ceux-ci paraîtra dans le rapport annuel 2016 qui sera publié au premier trimestre de 2017.

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COMMANDITAIRES - TOURNÉE DE CONFÉRENCIERS DE 2015

Contribution de l'ACP à partir du Fonds général
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Science Atlantic

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(SUPPLÉMENTS AUX PRIX PROVINCIAUX)

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TRIUMF, l'Institut Périmètre, Nelson Education et l'Association des ingénieurs et des géoscientifiques de la Colombie-Britannique.

PARTENAIRES - BOURSE 2015 DE L'INSTITUT PÉRIMÈTRE EN ENSEIGNEMENT DE LA PHYSIQUE, EN PARTENARIAT AVEC L'ACP ET L'IPP

(Le récipiendaire a été James Strachan, de l'École secondaire de Kelowna, en C.-B.)

L'ACP, l'Institut Périmètre et l'Institut de physique des particules

Nous rappelons au lecteur que les dons à la campagne 2016 de la FACP « Allumer la flamme » sont déductibles à des fins fiscales. La fondation Carswell Family Foundation offre généreusement d'égaler les dons faits en 2016, au-delà du niveau de 2015. Nous nous sommes fixé un objectif ambitieux de 50 000 $; en juillet 2016, nous en étions à 50 % de l'objectif. Tous peuvent faire un don en tout temps grâce au formulaire sécurisé en direct, à cette adresse (https://www.cap.ca/donate/), ou lors du renouvellement annuel de l'adhésion. Un reçu à des fins fiscales sera émis pour tout don de 10 $ ou plus.

MEET YOUR 2016-17 EXECUTIVE

PRESIDENT

Richard MacKenzie earned his Bachelor's degree in Engineering Science (physics option) from the University of Toronto in 1980. He obtained his PhD in Physics from the University of California, Santa Barbara in 1984. He remained there for a post-doc for one year, and following postdocs at DAMTP, Cambridge University, and at Ohio State University, he joined the faculty of the Département de physique of the Université de Montréal in 1989.

His main research area is theoretical particle physics, studying classical solutions of field theories and their quantum descendants. His work has touched upon applications in a variety of fields, including particle physics, condensed matter physics and cosmology. More recently, he has also worked in the field of quantum information.

Richard has taught a dozen courses over the years, at all levels of the undergraduate and graduate curricula. He has won his Department's teaching award on five occasions, as well as that of the Faculté des arts et des sciences of the Université de Montréal in 2012. He has been a member of CAP since 1994, and has served as chair of the Division of Theoretical Physics and as regional councillor for Quebec North and West. He has been co-organizer of several Theory Canada conferences, and was co-chair of the Local Organizing Committee of the 2013 CAP congress held at the Université de Montréal.

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VICE-PRESIDENT

Dr. Stephen Pistorius is a Professor of Physics and an Associate Professor of Radiology at the University of Manitoba (UM) and a Senior Scientist at CancerCare Manitoba (CCMB) and the Manitoba Institute of Cell Biology (MICB). Educated in South Africa, he holds B.Sc. (Physics & Geography), Hons. B.Sc. (Radiation Physics), M.Sc. (Medical Physics) and Ph.D. (Physics) degrees. He has experience in the military, in industry, health care and in academia. He is a certified Medical Physicist, a licensed Professional Physicist, and is a senior member of the IEEE and a fellow of the Canadian Organization of Medical Physics (COMP). Dr. Pistorius has served as the Treasurer and President of COMP, as the Director of Professional Affairs for the Canadian Association of Physicists and on many grant review committees. He is the Director of the CAMPEP accredited Medical Physics graduate program at the UM, and Vice Director of the UM Biomedical Engineering Graduate Program. His current research interests are in cancer imaging for both early detection and optimized radiation therapy. He holds a number of National Grants, has over 200 publications and presentations, is currently supervising 10 trainees and collaborates with and supports many more.

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VICE-PRESIDENT ELECT

Bruce D. Gaulin has been a faculty member at McMaster University since 1988, where he is currently Brockhouse Chair in the Physics of Materials and Director of the Brockhouse Institute for Materials Research. He received his BSc in Physics from McGill, before going on to McMaster for his PhD, working in neutron scattering studies of quantum materials – worked performed mainly at the Chalk River Laboratories. He has held sabbatical appointments at both Oak Ridge and Brookhaven National Labs in the USA. Prof. Gaulin served as President of the Canadian Institute for Neutron Scattering (1997-2003) and was elected President of the Neutron Scattering Society of America (2009-13).

A CAP member since his PhD days, Prof. Gaulin has served on CAP Council as a regional councilor (1990-92), Chair of DCMMP (1999-2000) and as Director of Academic Affairs (2006-09). He served as a member and Chair of NSERC GSC-28, and as NSERC Physics Group Chair (2010-13). He has served numerous science advisory roles in Canada and abroad, including on the Advisory Committee on TRIUMF (2006-10), as Chair of the Science Advisory Committee of the CLS (2004-08), and as Chair of Commission 10 (Structure and Dynamics of Condensed Matter) of IUPAP (2005-08).

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BUREAU DE L'ACP

VOTRE EXÉCUTIF POUR 2016-17

PRÉSIDENT

Richard MacKenzie se voit décerner un baccalauréat en sciences d'ingénierie (option physique) par l'Université de Toronto en 1980. En 1984, il obtient son doctorat en physique de l'Université de la Californie, à Santa Barbara, où il poursuit des études postdoctorales pendant un an et, à la suite d'études postdoctorales à DAMTP, à l'Université Cambridge et à l'Université de l'Ohio, il se joint au corps professoral du Département de physique de l'Université de Montréal en 1989.

Son principal domaine de recherche est la physique théorique corpusculaire, examinant les solutions classiques des théories des champs et leurs dérivés quantiques. Son travail gravite autour d'applications dans divers domaines, dont la physique corpusculaire, la physique de la matière condensée et la cosmologie. Dernièrement, il travaille aussi dans le domaine de l'information quantique.

Richard enseignera une dizaine de cours au fil des ans, à tous les niveaux des programmes de premier, deuxième et troisième cycles. Il remportera le prix en enseignement du Département à cinq reprises et celui de la Faculté des arts et des sciences de l'Université de Montréal en 2012.

Membre de l'ACP depuis 1994, il sera président de la Division de la physique théorique et conseiller régional pour le Nord et l'Ouest du Québec. Il sera coorganisateur de plusieurs conférences de Theory Canada et coprésident du Comité organisateur local du congrès de l'ACP tenu en 2013 à l'Université de Montréal.

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VICE-PRÉSIDENT

Le Dr Stephen Pistorius est professeur de physique et professeur agrégé de radiologie à l'Université du Manitoba (UM) ainsi que scientifique chevronné à Action cancer Manitoba et au Manitoba Institute of Cell Biology. Ses études en Afrique du Sud lui vaudront un B.Sc. (physique et géographie), un baccalauréat spécialisé en science (physique des rayonnements), une M.Sc. (physique médicale) et un doctorat (physique). Il possède de l'expérience dans les domaines militaire, industriel et universitaire et dans celui des soins de santé. Il est physicien médical agréé et phys. licencié ainsi que membre émérite de l'IEEE et membre de l'Organisation canadienne des physiciens médicaux (OCPM). Le Dr Pistorius occupera les postes de trésorier et président de l'OCPM et de directeur des affaires professionnelles pour l'Association canadienne des physiciens et physiciennes, et il siégera à nombre de comités d'examen des demandes de subvention. À l'UM, il dirige le programme d'études supérieures CAMPEP des physiciens médicaux agréés et il est vicedirecteur du Programme d'études supérieures en génie biomédical. Le Dr Pistorius axe actuellement ses recherches sur l'imagerie diagnostique du cancer pour la détection hâtive et la radiothérapie optimisée. Il est titulaire de diverses subventions nationales et auteur de plus de 200 publications et présentations. De plus, il supervise 10 stagiaires et collabore avec plusieurs autres, qu'il soutient également.

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VICE-PRÉSIDENT ÉLU

Bruce D. Gaulin est membre du corps professoral de l'Université McMaster depuis 1988 et y est actuellement président Brockhouse de la physique des matériaux et directeur du Brockhouse Institute for Materials Research. Il reçoit un baccalauréat en physique de McGill avant de faire un doctorat à McMaster, travaillant à des études sur la diffusion des neutrons de matériaux quantiques – effectuées principalement aux laboratoires de Chalk River. Le professeur Gaulin détient des nominations en période sabbatique au laboratoire d'Oak Ridge et au Laboratoire national de Brookhaven aux États-Unis. Il est président de l'Institut canadien de la diffusion des neutrons (1997-2003) et est élu président de la Neutron Scattering Society of America (2009-13).

Membre de l'ACP depuis ses études au doctorat, il siège au Conseil de l'ACP à titre de conseiller régional (1990-1992), de président de la DPMCM (1999-2000) et de directeur des Affaires académiques (2006-2009). Le professeur Gaulin est membre et président du GSC-28 du CRSNG et président du Groupe de physique du CRSNG (2010-2013). Il remplit de nombreux rôles consultatifs en science au Canada et à l'étranger, notamment au Comité consultatif de TRIUMF (2006-2010), à la présidence du Comité consultatif sur la science du Centre canadien de rayonnement synchrotron (2004-2008) et à la présidence de la Commission 10 (structure et dynamique de la matière condensée) de l'Union internationale de physique pure et appliquée (2005-2008).

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SUMMARY OF CAP PHYSICS DEPARTMENT SURVEY – 2015 BY DONNA STRICKLAND*, DIRECTOR OF ACADEMIC AFFAIRS

Since 2013, the Canadian Association of Physicists (CAP) has carried out an annual on-line survey of Canadian physics departments. The information collected by the survey from the past three years is stored in a CAP database that the department members can view at any time [1]. Each year a summary of the survey results is published in *Physics in Canada* [2,3]. Along with the basic data including number of students, number of faculty and number of staff, etc. there is a second section that looks at the graduate programs offered by the various departments. The information about the graduate programs is then part of an on-line directory of Canadian physics graduate programs that can be found on the CAP website [4].

There is still some ambiguity in some of the questions such as the number of BSc physics graduates. The number of graduating students jumped from 625 to 988 in the past year mostly because two of the larger departments changed their numbers this year to include majors as well as honours students. It is not clear then if other departments are counting just honours physics or also the majors. We have tried over the past years to lessen the ambiguity while not making the number of questions onerous for the respondents. We will consider adding a question to clarify honours and majors undergraduates as well as adding questions to determine the number of female undergraduate and graduate students. We currently only ask about the number of female faculty.

The results of the 2015 Department Survey are summarized in Table 1 and Fig. 1. Table 1 reports the number of departments responding and the average number of faculty per department. It also reports total numbers of BSc, MSc and PhD graduates, and the total number of physics faculty. Figure 1 plots (a) the number of single semester courses taught per faculty, (b) the number of BSc graduates (with the exception of one outlying data point of 300 students/40 faculty), (c) the number of graduate students, (d) the number of pdf's, and (e) the number of female faculty, all plotted as a function of number of faculty.

The main trends that we recently added to the survey and intend to expand on in next year's report are the percentage of female faculty and the percentage of teaching faculty to research faculty. We have only collected this data during the past two years and over that short time the percentages have not changed. During the same time period 29 new hires were reported which is just 4% of the total number of faculty so not a large change can be expected. The average numbers remain at 16% female faculty and 11% teaching faculty. There is a large spread in numbers of female faculty with the percentages ranging from 0 to 40%.

TABLE 1
SUMMARY OF RESULTS OF CAP PHYSICS DEPARTMENT SURVEY – 2015.

Number of Departments Reporting	39 (66%)
Total Number of Faculty	702
Average Number of Faculty	18
Smallest Number of Faculty	4
Largest Number of Faculty	62
Total Number of Research Faculty	623 (89%)
Total Number of Female Faculty	113 (16%)
Total Number of New Faculty	29
Total Number of PDFs / RAs	318/190
Total # of BSc Graduates / Year	988
Total # of MSc Graduates / Year	253
Total # of PhD Graduates / Year	212

Over the next few years, we hope this survey will help determine trends in physics participation across Canada. The trends will be easier to determine if **all** Physics departments in Canada participate in the survey. In the past two years, we have had 39 departments fill out the survey each year, but only 30 departments participated both years. There are a total of 59 departments, so we are only tracking 51% of the academic physics community consistently. I do want to thank all the departments that took the time to fill out the survey and I would like to encourage all the departments to take part in the coming years.

I would like to express my appreciation to the CAP staff who supported the development and analysis of the survey.

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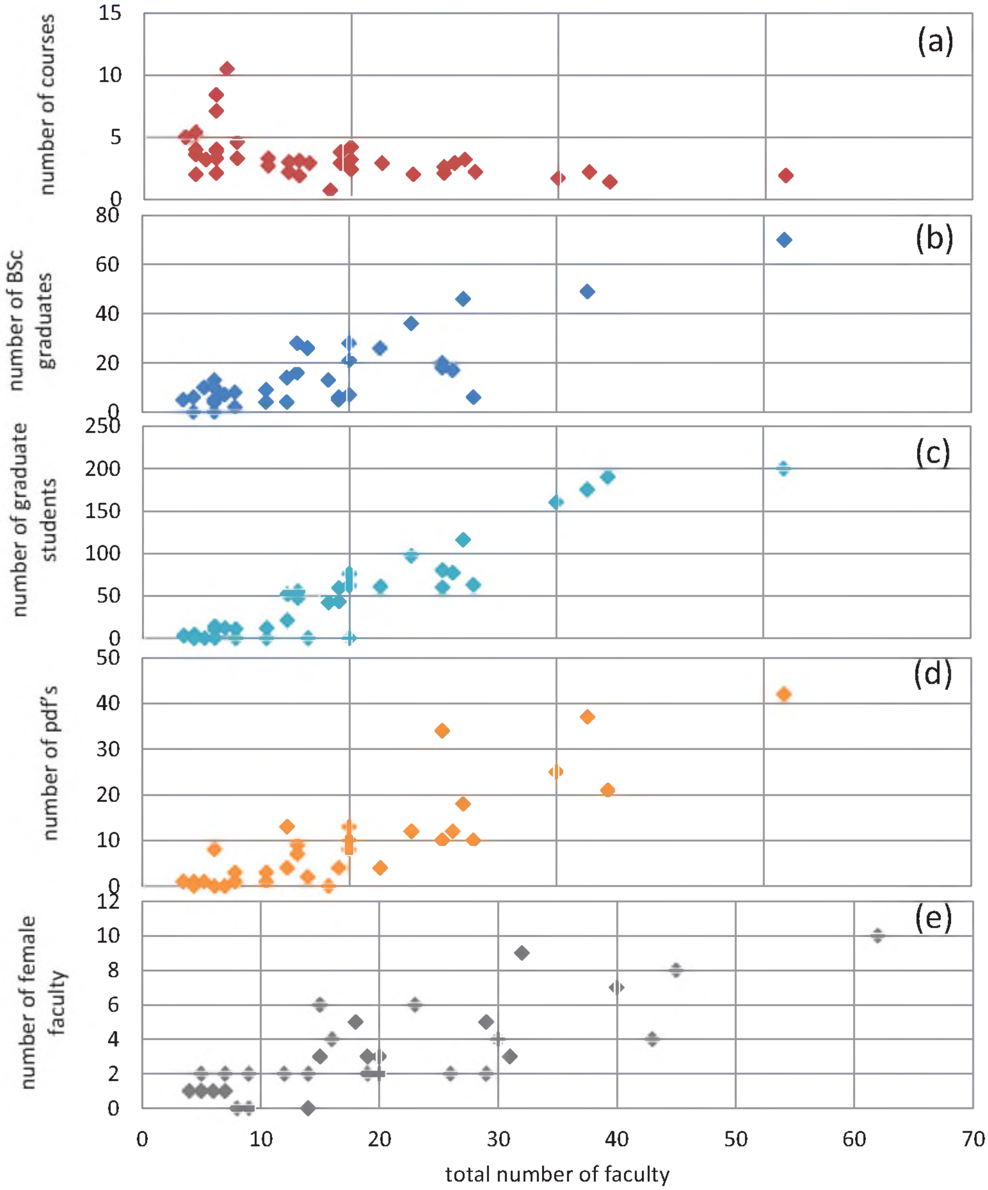


Fig. 1 (a) Number of course sections (one semester courses or equivalent) taught per faculty member per year; (b) Number of BSc graduates per year; (c) Number of grad students enrolled; (d) Number of postdoctoral fellows; and (e) Number of female faculty members, for Canadian physics departments, plotted as a function of the number of faculty members.

REFERENCES

1. Departments can access the Survey through the Member Services Login page (https://www.cap.ca/services/) using their department id and password. For help with this, please contact the CAP Office: capmgr@uottawa.ca.
2. Barbara Frisken, "Summary of CAP Physics Department Survey 2013", *Physics in Canada* **70**, 198 (2014).
3. Barbara Frisken, "Summary of CAP Physics Department Survey 2014", *Physics in Canada* **71**, 214 (2015).
4. http://www.cap.ca/en/students-educators/graduate-programs

Science Policy Update by Aimee Gunther and Kris Poduska

Science policy is not defined solely as the shaping of government policies towards funding science. Nevertheless, many Canadian physicists are acutely aware of the critical role that governmental financial support for research plays in academic environments, government labs, and industrial settings. By working with a committee of dedicated and enthusiastic volunteers through the CAP's Science Policy Committee over the last two years, we have helped the CAP to engage with funding bodies (NSERC and CFI) about the needs and concerns of Canada's physics community. To ensure that our voices continue to be heard and respected, all of us have a role to play.

First and foremost, **do good science**. Collaborate with others near and far, be ambitious, and aim high.

Second, **talk to the public about your work**. Inform kids, parents, university administrators, politicians, and social networks of the great science being done here in Canada.

Finally, **be engaged citizens**. Vote. Give feedback and positive reinforcement to local, provincial, and federal governments.

Le point sur la politique scientifique par Aimee Gunther et Kris Poduska

La politique scientifique ne se définit pas seulement par l'orientation des politiques gouvernementales vers le financement de la science. Néanmoins, de nombreux physiciens canadiens sont trés conscients du rôle essentiel que joue l'aide financiére du gouvernement á la recherche en milieux universitaire et industriel et dans les laboratoires de l'État. Notre collaboration des deux dernières années avec un comité de bénévoles dévoués et enthousiastes, par l'entremise du Comité de la politique scientifique de l'ACP, a aidé l'Association á s'engager, avec les organismes de financement (CRSNG et FCI), á répondre aux besoins et préoccupations de la collectivité canadienne de la physique. Pour assurer que nos voix continuent d'être entendues et respectáes, chacun de nous a un rôle á jouer.

Avant tout, **notre démarche scientifique doit être bonne**. Il nous faut collaborer avec les autres, proches ou éloignés, être ambitieux et viser haut.

En second lieu, **nous devons faire connaître nos travaux au public** : informer les enfants, les parents, les administrateurs d'université, les politiciens et les réseaux sociaux des merveilles scientifiques qui se font au Canada même.

Enfin, **il nous faut être des citoyens engagés**. Votez. Faites part de vos commentaires et donnez un renforcement positif aux administrations municipales, provinciales et fédérale.

Would you like to know more about the CAP's role in shaping science policy? Are you interested in getting involved? In either case, please feel free to get in touch (kris@mun.ca).

Aimeriez-vous en savoir davantage sur le rôle de l'ACP dans l'orientation de la politique scientifique? Êtes-vous intéressé à jouer un rôle actif? Dans l'un et l'autre cas, n'hésitez pas à communiquer avec nous (kris@mun.ca).

Aimee Gunther is a member of the Science Policy Committee and Kris Poduska is the CAP's Director of Science Policy.

Aimee Gunther est membre du comité de la politique scientifique; Kris Poduska est directrice de la politique scientifique.

LE COIN DE LA POLITIQUE SCIENTIFIQUE

CALL FOR NOMINATIONS FOR THE CAP BOARD OF DIRECTORS AND ADVISORY COUNCIL

DEADLINE: 30 November 2016

Are you interested in having a voice in the management of the CAP? Do you want to help define the priorities of your association? The CAP is currently seeking nominees for election to positions that are opening up in June 2017 on the CAP's Board of Directors and Advisory Council.

Deadline for the submission of expressions of interest is November 30, 2016. The CAP Nominating Committee will circulate a proposed slate of nominations by March 1, 2017.

Nomination forms (available at http://www.cap.ca/en/about-cap/call-nominations-2017) must be signed by the nominee as well as two CAP members who support the nomination, and must be sent by e-mail, along with a short biography, to capmgr@uottawa.ca.

The full list of nominations we are seeking to assemble appears directly below:

CAP Board of Directors Positions to be filled:

- Vice-President Elect (4-year progression through Presidential line)
- Director of International Affairs (3-year term)
- Director of Professional Affairs (3-year term)
- Secretary-Treasurer (remainder of 3-year term ending June 2019)

Advisory Council Positions to be filled:

- Councillor representing Student Affiliates, 1-year term – normally the CUPC 2017 Chair (elected at CUPC 2016)
- Regional Councillors – one for each region (2-year term), to work with councillors who are starting their 2nd year:
  - British Columbia and Yukon
  - Alberta, Northwest Territories and Nunavut
  - Saskatchewan and Manitoba
  - Ontario - Southwest (Note: Both positions are currently vacant.)
  - Ontario - Central and North
  - Ontario - East
  - Quebec - North and West
  - Quebec - South and East
  - New Brunswick, Newfoundland and Labrador
  - Nova Scotia and Prince Edward Island

A list of current directors and councillors can be found at: http://www.cap.ca/en/about-us/

APPEL DE CANDIDATURES POUR LE CONSEIL D'ADMINISTRATION ET LE CONSEIL CONSULTATIF DE L'ACP

ÉCHÉANCE : 30 novembre 2016

Vous voulez avoir voix au chapitre dans la direction de l'ACP? Vous désirez définir les priorités de votre association? L'ACP est á la recherche de candidats pour élection aux postes à combler au Conseil d'administration et au Conseil consultatif débutant en juin 2017.

L'échéance pour la présentation des candidatures est le 30 novembre 2016. Le comité de candidatures de l'ACP émettra la liste des candidatures proposées le 1er mars 2017.

Les formulaires de candidature (disponibles au http://www.cap.ca/fr/propos-lacp/appel-candidatures-2017) doivent être signés par le candidat et deux membres de l'ACP qui supportent la candidature, puis envoyés par courriel, accompagnés d'une brève notice biographique, à l'adresse capmgr@uottawa.ca.

La liste complète des postes à combler se trouve juste ci-dessous :

Postes à combler au Conseil d'administration :

- Vice-président élu (terme de 4 ans avec progression dans la ligne présidentielle)
- Directeur des Affaires internationales (terme de 3 ans)
- Directeur des Affaires professionnelles (terme de 3 ans)
- Secrétaire-Trésorier (reste du terme de 3 ans se terminant en juin 2019)

Postes à combler au Conseil consultatif :

- Conseiller représentant les étudiants affiliés, terme d'un an – habituellement le président de CUPC 2017 (élu à CUPC 2016)
- Conseillers régionaux – un pour chaque région (terme de 2 ans) travaillent en collaboration avec les conseillers débutant leur 2^{e} année de mandat :
  - Colombie-Britannique et Yukon
  - Alberta, Territoires du Nord-Ouest et Nunavut
  - Saskatchewan et Manitoba
  - Ontario - Sud-ouest (Note : les deux postes sont vacants)
  - Ontario - Central et Nord
  - Ontario - Est
  - Québec - Nord et Ouest
  - Québec - Sud et Est
  - Nouveau-Brunswick et Terre-Neuve-et-Labrador
  - Nouvelle-Écosse et l'Île-du-Prince-Édouard

La liste actuelle des membres du conseil d'administration et conseil consultatif peut être trouvée au : http://www.cap.ca/fr/propos-nous/

NEWS FROM THE CANADIAN NATIONAL IUPAP LIAISON COMMITTEE

*NOUVELLES DU COMITÉ NATIONAL CANADIEN DE LIAISON AVEC L'UIPPA (CNILC)**

The Canadian National IUPAP Liaison committee (CNILC) met during the CAP congress in Ottawa in June. The meeting led by committee chairman Jens Dilling was attended by the CAP president, the CNILC CAP committee representatives who cover the various physics areas, Canadian IUPAP commission and working group members as well as physicists who were hoping to obtain IUPAP funding for conferences to be held in Canada over the next few years. During the meeting a variety of topics were discussed, including the future international conferences in Canada, the work of the various IUPAP commissions and how to better advertise the young scientist prizes that are awarded by the individual IUPAP commissions so that deserving young Canadian scientists would be nominated.

NOMINATIONS FOR TWO POSITIONS ON THE CNILC

At this time, the CNILC is looking for candidates to represent the following areas on the committee for the June 2017-June 2020 term.

(a) General Physics which represents the Division of Atomic, Molecular and Optical Physics, the Division of Plasma Physics, the Division of Instrumentation and Measurement Physics and the Division of Atmospheric and Space Physics.

(b) Theoretical and Mathematical Physics which represents the Division of Theoretical Physics.

Formal letters of nomination that include the nominee's curriculum vitae and a brief description of the nominee's involvement in international activities, should be sent to the Executive Director of the Canadian Association of Physicists, 555 King Edward Avenue, 3rd Floor, Ottawa, Ontario, Canada, K1N 7N5, cap@uottawa.ca, no later than 1 December 2016.

More details about the work of the CNILC as well as links to obtain more information can be obtained at http://www.cap.ca/en/about-us/committees/cdn-natl-iupap-liaison-cttee

For questions or comments about the CNILC you can also contact the Chair, Jens Dilling, directly at JDilling@triumf.ca.

Jens Dilling, CAP's Director of International Affairs and Chair, CNILC
Andrew Sachrajda, Secretary, CNILC

Le comité national canadien de liaison avec l'UIPPA (CNILC) s'est réuni lors du Congrès de l'ACP à Ottawa en juin. Le président de l'ACP, des membres du comité représentant diverses sous-disciplines de la physique, des membres de la Commission canadienne et groupes de travail de l'UIPPA ainsi que des physiciens et physiciennes qui espéraient obtenir des subventions de l'UIPPA pour l'organisation de futures conférences au Canada ont assisté à la réunion dirigée par le président du comité Jens Dilling. Différents sujets ont été abordés pendant cette réunion, tel que les conférences internationales à venir au Canada, le travail des diverses commissions de l'UIPPA et comment améliorer la promotion des prix pour jeunes physiciens et physiciennes décernés par chaque commission de l'UIPPA afin d'assurer la nomination de jeunes scientifiques canadiens méritants.

APPEL DE CANDIDATURES POUR DEUX POSTES AU CNILC

Nous recherchons présentement des candidatures pour représenter les disciplines suivantes au sein du comité de juin 2017 à juin 2020.

(a) Physique générale qui représente la Division de la physique atomique, moléculaire et photonique, la Division de la physique des plasmas, la Division de la physique des instruments et mesures et la Division de la physique atmosphérique et de l'espace.

(b) Physique théorique et mathématique qui représente la Division de la physique théorique

Une lettre officielle de mise en candidature incluant le curriculum vitae du candidat et une courte description de son implication au sein d'activités d'envergure internationale devra être envoyée par courriel avant le 1^er^ décembre 2016 à la directrice exécutive de l'Association canadienne des physiciens et physiciennes, 555, ave. King Edward, 3e étage, Ottawa, Ontario, Canada, K1N 7N5, cap@uottawa.ca.

Pour plus de détails sur le CNILC et d'autres informations se trouvent au http://www.cap.ca/fr/propos-nous/comites/liaison-avec-uippa

Si vous avez des questions ou commentaires au sujet du CNILC vous pouvez aussi communiquer directement avec le président Jens Dilling à JDilling@triumf.ca.

Jens Dilling, directeur des affaires internationales de l'ACP et président du CNILC
Andrew Sachrajda, secrétaire du CNILC

* Canadian National IUPAP Liaison Committee

CALL FOR NOMINATIONS FOR THE 2017 CAP MEDALS

Each year, the CAP recognizes established researchers, promising scientists, and exceptional teachers for their outstanding contributions. Consider nominating a worthy colleague to receive one of the CAP medals being awarded in 2017 (see below). Visit the medal page at (http://www.cap.ca/activities/medals-and-awards) to view the guidelines and what material is required in support of a nomination.

CAP Medal for Lifetime Achievement in Physics
for distinguished service to physics over an extended period of time, and/or recent outstanding achievement

CAP Herzberg Medal
for outstanding achievement in any field of research by a Canadian physicist who has successfully defended their doctoral thesis within the last 12 years at the time of the award

CAP-DCMMP Brockhouse Medal
for outstanding experimental or theoretical contributions to condensed matter and materials physics

CAP Medal for Outstanding Achievement in Industrial and Applied Physics
to recognize and promote the creativity of scientists working in Canada in the area of industrial and applied physics

CAP-COMP Peter Kirkby Memorial Medal
for outstanding service to the Canadian physics community

CAP-CRM Prize
for research excellence in the fields of theoretical and mathematical physics

CAP-TRIUMF Vogt Medal
for outstanding experimental or theoretical contributions to subatomic physics

CAP Medal for Excellence in Teaching Undergraduate Physics

Deadline for nominations for the medals mentioned above is NOVEMBER 15, 2016.

APPEL DE CANDIDATURES POUR LES MÉDAILLES DE L'ACP 2017

Chaque année, l'ACP reconnaît l'excellence de chercheurs confirmés, de scientifiques prometteurs et d'enseignants exceptionnels. Encouragez un collègue digne de recevoir l'une des médailles 2017 de l'ACP (voir ci-dessous) en soumettant sa candidature. Consultez la page Web traitant des médailles et prix au http://www.cap.ca/fr/activites/medailles-bourses afin de prendre connaissance des directives concernant le matériel requis pour appuyer une candidature.

La Médaille de l'ACP pour contributions exceptionnelles de carrière à la physique
pour une contribution remarquable en physique au cours d'une période prolongée, et/ou pour une contribution exceptionnelle récente

La Médaille Herzberg
pour une contribution exceptionnelle dans un domaine quelconque de la recherche, à un physicien qui doit avoir soutenu avec succès leur thèse de doctorat au cours des 12 dernières années dès la date de la médaille.

La Médaille Brockhouse de l'ACP-DPMCM
pour l'excellence dans le domaine de la recherche théorique ou expérimentale en physique de la matière condensée et des matériaux.

La Médaille de l'ACP pour des réalisations exceptionnelles en physique industrielle et appliquée
pour reconnaître et de promouvoir la créativité des scientifiques qui travaillent au Canada en physique industrielle et appliquée

La Médaille commémorative Peter Kirkby
pour services exceptionnels à la communauté de la physique au Canada

Le Prix ACP-CRM
pour l'excellence dans le domaine de la recherche en physique théorique et mathématique

La Médaille Vogt de l'ACP-TRIUMF
pour l'excellence dans le domaine de la recherche théorique ou expérimentale en physique subatomique

La Médaille de l'ACP pour l'excellence en enseignement de la physique au premier cycle

La date limite des mises en candidature pour les médailles ci-dessus est le 15 NOVEMBRE 2016

CALL FOR NOMINATIONS FOR 2017 CAP AWARD FOR EXCELLENCE IN TEACHING HIGH SCHOOL/CÉGEP PHYSICS

Each year, the CAP and CAP Foundation, in partnership with our national and regional sponsors, recognize exceptional high school / cégep physics teachers in five regions across Canada. The award includes two free years as a CAP teacher member and an educational grant that can be used to support professional development for the teacher or to purchase computer software, equipment or books for the classroom.

CAP AWARD FOR EXCELLENCE IN TEACHING HIGH SCHOOL/CÉGEP PHYSICS

Please encourage anyone you know with children in high school or CÉGEP who has an outstanding physics teacher to consider nominating them for the High School/CÉGEP award!

Please visit http://www.cap.ca/en/HSCTA for more information about this award.

Deadline for nominations for these awards is FEBRUARY 25, 2017.

APPEL DE CANDIDATURES POUR LE PRIX D'EXCELLENCE EN ENSEIGNEMENT DE LA PHYSIQUE AU SECONDAIRE ET AU COLLÉGIAL DE L'ACP 2017

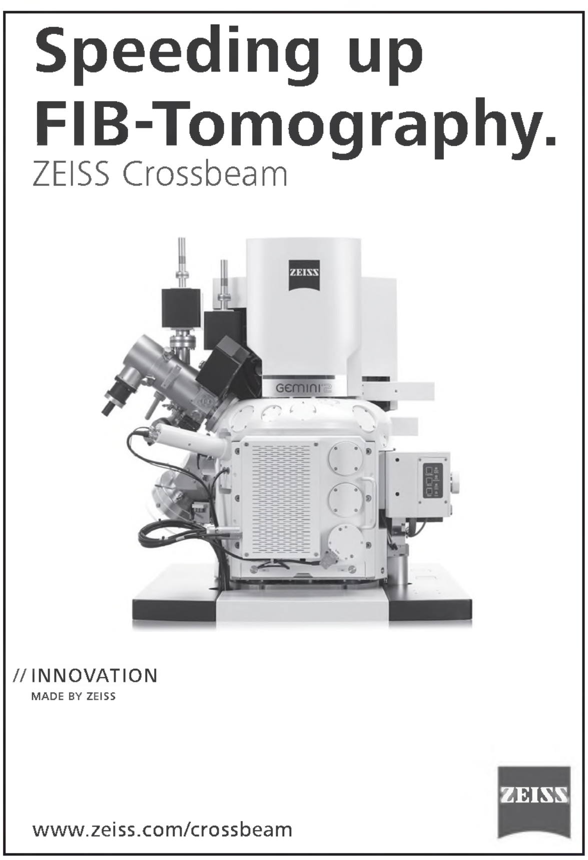
Chaque année, l'ACP et la Fondation de l'ACP, en collaboration avec ses partenaires nationaux et provinciaux, reconnaît les compétences exceptionnelles d'enseignants de physique au secondaire ou au collégial dans cinq régions du Canada. Le prix comprend deux années gratuites à titre d'enseignant membre de l'ACP et une subvention qui peut être utilisée pour le développement professionnel de l'enseignant, ou pour acheter des logiciels, du matériel ou des livres pour la salle de classe ou le laboratoire.

PRIX ACP D'EXCELLENCE EN ENSEIGNEMENT DE LA PHYSIQUE AU SECONDAIRE ET AU COLLÉGIAL

Si vous connaissez des élèves au secondaire ou des étudiants au cégep qui ont un professeur de physique exceptionnel, encouragez-les à soumettre leur candidature pour le prix d'excellence en enseignement de la physique au secondaire et au collégial!

Pour plus d'informations sur ce prix, vous êtes invités à visiter le site web à l'adresse http://www.cap.ca/fr/PESC.

La date limite des mises en candidature pour ces prix est le 25 FÉVRIER 2017.



URSULA FRANKLIN (1921-2016)

A VERY PERSONAL MEMOIR OF AN EXTRAORDINARY WOMAN

BY MICHAEL STEINITZ

One of my first and fondest memories of Ursula is from our first meeting in 1972 when I saw the sign over her desk that said, "I am a Quaker. In case of emergency, please be quiet!" It pretty well describes Ursula's quiet strength in the face of any difficulty. My last is of a lunch with Ursula and my wife, Heidi, a month before Ursula died, at which her wisdom and insight shone as ever.

Ursula's biography can be read in recent summaries in the Globe and Mail [1] and MacLean's magazine [2] on the CBC [3], and in Wikipedia [4]. The list of honours and recognitions is long. Interestingly, she was brought to Canada by a very important Canadian institution, the Lady Davis Trust, the same organization that built the Student Union building at St. Francis Xavier University and twice provided a visiting professorship for me at the Technion in Israel.

Ursula's life was defined and formed by experience and judgement. Her experience of discrimination and imprisonment under a fascist dictatorship in Nazi Germany shaped her lifelong opposition to oppression of any form and to militarism and war. Coming from a Jewish and Lutheran background, she gravitated to the pacifism of the Quakers. As she often said, "War is stupid." She would have laughed at the idea of "saintliness" and her family is the first to point out that she shouldn't be seen as a saint. She was an inspiration, a mentor, and a force for change, but it was possible to disagree with her and still have her respect. We disagreed on many things!

Ursula was a consummate rationalist and gave an inspiring commencement address at St. Francis Xavier University when she received one of her many honorary degrees. She spoke about the importance of numeracy and it led clearly to the importance of evidence-based decision-making.

Ursula's doctorate from the Technical University of Berlin was supervised by Professor Richard Becker. Becker was also my father's thesis supervisor. Becker helped to save my father's life by arranging for him to give a seminar at NYU in New York City and advising him to buy a one-way ticket. (Becker also supervised the thesis of Simon Fraser University's professor Tony Arrott at Carnegie Mellon University after the war.) When I first met Ursula we talked about the fact that my wife and my father shared the experience of having been nourished after the war by "Quakerspeisung", the school lunches that the Quakers provided to school children in Germany who would otherwise have starved. The experience was shared, but one was from after the First World War and the other from after the Second World War. We shared the joys of our shared German language and of a certain kind of German folding kayak.

Many will recall Ursula's inspiring talks at the CAP Congress in Toronto in 2010 [5] and at the International Conference on Women in Physics in Waterloo in 2014. One of my favourite students, wavering on the brink of changing fields after graduation, was inspired to remain in physics by meeting and hearing Ursula at ICWIP2014. For this, as for so many things, I am very grateful.

Michael Steinitz, editor of the *Canadian Journal of Physics*
Emeritus Professor of Physics at St. Francis Xavier University

REFERENCES

1. *The Globe and Mail*, July 25, 2016.
2. *MacLean's* Magazine July 25, 2016.
3. http://www.cbc.ca/news/canada/toronto/ursula-franklin-dead-1.3692502
4. https://en.wikipedia.org/wiki/Ursula_Franklin
5. *Physics in Canada* **66**(3): 171-173 (2010).

Marek J. Laubitz (1931-2016)

by Chandre Dharma-wardana

With the recent passing of Marek Laubitz, the scientific community loses a brilliant physicist with a long and distinguished career at the National Research Council of Canada (NRC). Dr. Laubitz, Mark to his colleagues, studied Engineering Physics at the University of Toronto and graduated with honours; he received several awards, including an Athlone Fellowship to study Nuclear Physics at the famous Cavendish Laboratory of Cambridge University, where he received his PhD in 1956. He then returned to Canada to join the Division of Physics, NRC, and work as a Postdoctoral Fellow with Dr. D.K.C. MacDonald, a world leader in in the field of electrical, thermal and related transport properties of materials.

In 1958 he was invited to join the permanent staff of the Division of Physics. This was the beginning of a distinguished research career, which in the period 1959-1980 resulted in more than 150 scholarly publications, which retain their influence up to the present day. Publications such as *The transport properties of powders* (1959), *Analysis of glow curves* (1967), and *Exact solutions of the kinetic equations governing thermally stimulated luminescence* (1971) are still regularly cited in the recent literature; they have been of crucial importance in the design of precision furnaces that provide for accurate compensation of radiative losses. His research papers provided and still provide benchmark data for metrology and industrial metallurgy. His measurements of resistivities of metals at temperatures up to the melting point are still cited. Mark's work was characterized by attention to detail and imaginative use of theory in designing experiments and new tools. This painstaking work enabled him to sort out some of the deep many-body effects that influence transport properties of metals. His work on deviations from Matthiessen's rule, or the role of electron-electron interactions in causing deviations from the Wiedemann-Franz law were high-water marks of his fundamental scientific work in this area.

The study of transport properties of clathrates, i.e. ice structures crystallized such that they contain a network of cages in which natural gas molecules are embedded and which thus form, potentially, a major source of future energy, was a final topic that his research team undertook before he became the Director of the Division of Physics, later reorganized as the Institute of Microstructural Sciences. He showed great management skills in leading NRC towards the emerging field of nanotechnology and installed the very first Molecular Beam Epitaxy machine in Canada. The Canadian banknotes with holographic security films were developed at the NRC in the early 1980s by a team led by Mark. During the reorganization of NRC in 1991, he was selected to be the Director General of the newly formed Steacie Institute of Molecular Sciences, with a mandate to carry out fundamental research on molecular matter, in which chemists and physicists combined their efforts. Again he showed great leadership and created an institute that gained high international prestige. Mark retired from NRC in 1994 but continued to shine as a manager of the Ontario Centre of Excellence for Photonics, prior to his resettling in Niagara-on-the-Lake. He is survived by his wife Diana, three children and one grandchild and will be remembered by his colleagues as a dedicated scientist and an admired leader.

Chandre Dharma-wardana
NRC and Université de Montréal

In Memorium

Book Review Policy

Books may be requested from the Book Review Editor, Richard Marchand, by using the online book request form at http://www.cap.ca.

CAP members are given the first opportunity to request books. For non-members, only those residing in Canada may request a book. Requests from non-members will only be considered one month after the distribution date of the issue of *Physics in Canada* in which the book was published as being available.

The Book Review Editor reserves the right to limit the number of books provided to reviewers each year. He also reserves the right to modify any submitted review for style and clarity. When rewording is required, the Book Review Editor will endeavour to preserve the intended meaning and, in so doing, may find it necessary to consult the reviewer. Reviewers submit a 300-500 word review for publication in PiC and posting on the website; however, they can choose to submit a longer review for the website together with the shorter one for PiC.

La politique pour la critique de livres

Si vous voulez faire l'évaluation critique d'un ouvrage, veuillez entrer en contact avec le responsable de la critique de livres, Richard Marchand, en utilisant le formulaire de demande électronique à http://www.cap.ca.

Les membres de l'ACP auront priorité pour les demandes de livres. Ceux qui ne sont pas membres et qui résident au Canada peuvent faire une demande de livres. Les demandes des non-membres ne seront examinées qu'un mois après la date de distribution du numéro de la Physique au Canada dans lequel le livre aura été déclaré disponible.

Le Directeur de la critique de livres se réserve le droit de limiter le nombre de livres confiés chaque année aux examinateurs. Il se réserve, en outre, le droit de modifier toute critique présentée afin d'en améliorer le style et la clarté. S'il lui faut reformuler une critique, il s'efforcera de conserver le sens voulu par l'auteur de la critique et, à cette fin, il pourra juger nécessaire de le consulter. Les critiques pour publication dans la PaC doivent être de 300 à 500 mots. Ces critiques seront aussi affichées sur le web ; s'ils le désirent les examinateurs peuvent soumettre une plus longue version pour le web.

Books Received / *Livres reçus*

The following titles are a sampling of books that have recently been received for review. Readers are invited to write reviews, in English or French, of books of interest to them. Unless otherwise indicated, all prices are in Canadian dollars.

Lists of all books available for review, books out for review and book reviews published since 2000 are available on-line at www.cap.ca (Publications).

In addition to books listed here, readers are invited to consider writing reviews of recent publications, or comparative reviews on books in topics of interest to the physics community. This could include for example, books used for teaching and learning physics, or technical references aimed at professional researchers.

Les titres suivants sont une sélection des livres reçus récemment aux fins de critique. Nous invitons nos lecteurs à nous soumettre une critique en anglais ou en français, sur les sujets de leur choix. Sauf indication contraire, tous les prix sont en dollars canadiens.

Les listes de tous les livres disponibles pour critique, ceux en voie de révision, ainsi que des critiques publiées depuis 2000 sont disponibles sur : www.cap.ca (Publications).

En plus des titres mentionnés ci-dessous, les lecteurs sont invités à soumettre des revues sur des ouvrages récents, ou des revues thématiques comparées sur des sujets particuliers. Celles-ci pourraient par exemple porter sur des ouvrages de nature pédagogique, ou des textes de référence destinés à des professionnels.

GENERAL INTEREST

A lesson for the Future of Our Science: My Testimony on Lord Patrick M S Blackett, Antonino Zichichi, World Scientific Publishing Co. Pte. Ltd., 2016; pp. 278; ISBN: 9789814719414; Price: 26.79.

In Praise of Simple Physics: The Science and Mathematics behind Everyday Questions, Paul J. Nahin, Princeton University Press, 2016; pp. 272; ISBN: 9780691166933; Price: 37.95.

Introduction to Modern Climate Change, Andrew Dessler, Cambridge University Press, 2016; pp. 270; ISBN: 9781107480674; Price: 62.95.

Mathematical Methods for Geophysics and Space Physics, William I. Newman, Princeton University Press, 2016; pp. 272; ISBN: 9780691170602; Price: 93.95.

Où se cachent les nanos?, Nadia Capolla, MultiMondes, 2016; pp. 213; ISBN: 978-2-89544-549-4; Price: 27.95.

Pursuing Sustainability: A Guide to the Science and Practice, Pamela Matson, William C. Clark & Krister Andersson, Princeton University Press, 2016; pp. 239; ISBN: 9780691157610; Price: 38.97.

The Cosmic Cocktail: Three Parts Dark Matter, Katherine Freese, Princeton University Press, 2014; pp. 264; ISBN: 9780691169187; Price: 37.95.

The Scientist's Guide to Writing: How to Write More Easily and Effectively throughout Your Scientific Career, Stephen B. Heard, Princeton University Press, 2016; pp. 306; ISBN: 9780691170220; Price: 30.95.

UNDERGRADUATE TEXTS

200 More Puzzling Physics Problems: With Hints and Solutions, Peter Gnädig, Gyula Honyek and Máté Vigh, Cambridge University Press, 2016; pp. 496; ISBN: 9781107503823; Price: 33.95.

A First Course in Mathematical Physics, Colm T. Whelan, Wiley, 2016; pp. 336; ISBN: 978-3-527-41333-1; Price: 96.

A Student's Manual for A First Course in General Relativity, Robert B. Scott, Cambridge University Press, 2016; pp. 320; ISBN: 9781107638570; Price: 45.95.

GRADUATE TEXTS AND PROCEEDINGS

60 Years of Yang-Mills Gauge Field Theories: C.N. Yang's Contributions to Physics, L. Brink and K.K. Phua, World Scientific Publishing Co. Pte. Ltd., 2016; pp. 538; ISBN: 9789814725552; Price: 67.95.

Fundamentals of Sum-Frequency Spectroscopy, Y.R. Shen, Cambridge University Press, 2016; pp. 331; ISBN: 9781107098848; Price: 160.95.

Heliophysics: Active stars, their Astrospheres, and Impacts on Planetary Environments, Carolus J. Schrijver, Frances Bagenal and Jan J. Sojka, Cambridge University Press, 2016; pp. 396; ISBN: 9781107090477; Price: 68.95.

Particle Physics of Brane Worlds and Extra Dimensions, Sreerup Raychaudhuri and K. Sridhar, Cambridge University Press, 2016; pp. 341; ISBN: 9780521768566; Price: 102.95.

Physics of Partially Ionized Plasmas, Vinod Krishan, Cambridge University Press, 2016; pp. 274; ISBN: 9781107117396; Price: 126.95.

Scintillation Dosimetry, Sam Beddar and Luc Beaulieu, CRC Press; Taylor and Francis Group, 2016; pp. 435; ISBN: 9781482208993; Price: 91.07.

Supersymmetry and String Theory: Beyond the Standard Model, Michael Dine, Cambridge University Press, 2015; pp. 503; ISBN: 9781107048386; Price: 108.95.

Book Reviews / *Critique de livres*

Book reviews for the following books have been received and posted to the Physics in Canada section of the CAP's website: http://www.cap.ca. When available, the url to longer versions are listed with the book details.

Des revues critiques ont été reçues pour les livres suivants et ont été affichées dans la section "La Physique au Canada" de la page web de l'ACP: http://www.cap.ca. Quand disponible, un lien url à une critique plus longue est indiqué avec les détails du livre.

Elements of Slow-Neutron Scattering by J. M. Carpenter and C.-K. Loong, Cambridge University Press, 2015, ISBN: 978-0-521-85781-9, price: 200.95.

Neutron scattering research has a long and storied tradition in Canada, and almost all readers of Physics in Canada will be familiar with the Nobel Prize awarded for the pioneering work of Bertram N. Brockhouse. In recent years the field has been reinvigorated in North America with the construction of the accelerator based Spallation Neutron Source and upgraded facilities at the major American reactor based sources. Thus the scientific opportunities are plentiful, and the arrival of a fresh new book on the subject is very timely. Elements of Slow-Neutron Scattering, Basics, Techniques, and Applications, is a collaborative effort of J. M. Carpenter, whom many regard as the "father of pulsed neutron scattering", and C.-K. Loong, who enjoyed a long and distinguished career as a practitioner of the technique. They have produced a very ambitious book, more than 500 pages long, with an enormous amount of supplemental information at the website http://slowneutronscattering.com. The book refers frequently to the website, which, in turn has keywords cross-indexed to the book chapters. This combination was quite an undertaking!

To misquote a hackneyed phrase, "this ain't your thesis supervisor's neutron scattering book". Most books on the subject start out with a short overview of the neutron itself, possibly some elementary information about sources, detection and instruments, then move onto scattering cross-sections, diffraction, and then more specialized applications. Elements of Slow-Neutron Scattering seems to begin this way, then (boom!), the reader of chapter 1 is immersed in a detailed discussion of neutron transport theory. By the time I made it to the Greuling- Goertzel approximation my head was spinning. I was surprised to see this much detailed material in the opening chapter, but setting aside its placement in the opening chapter, this is significant information that is not easily accessible elsewhere. This is followed up in the second chapter by an exposition of neutron sources, moderators, and pulsed source line-shapes. From that point on the book moves into more familiar territory, first covering scattering theory, then instruments, optical devices and detectors. The book is rounded out with several chapters on applications, including crystallography, lattice dynamics and chemical spectroscopy, magnetic structures and excitations, and disordered and large scale structures.

For the most part the book is very readable, with mild eccentricities that I suspect most readers will find enjoyable although a few may find them distracting. Examples include a short digression in the introduction, "for want of a better place to do so", mentioning that Tesla discovered x-rays before Roentgen but failed to publish, and later on starting the discussion of the neutron's magnetic moment with a quantum state vector written explicitly in terms of quark states. Most books on neutron scattering take the spin 1/2 as a given and leave it at that. In places the authors' seem to have melded the rigor of a mathematically inclined physicist and the practical approach of an engineer with the soul of a philosopher-poet.

One might ask how this book compares with others available covering similar material as the comprehensive books Theory of Thermal Neutron Scattering by Marshall and Lovesey and Lovesey's two-volume follow-up Theory of Neutron Scattering from Condensed Matter have been definitive and provided detailed expositions of the theoretical aspects of slow neutron scattering. A more accessible book for those starting out is Squires' Introduction to the Theory of Thermal Neutron Scattering. Readers desiring an understanding of the information gleaned from neutron scattering but relatively uninterested in details of the experiments themselves would probably be satisfied by one of these.

More experimentally oriented books include the specialized Neutron Scattering with a Triple-Axis Spectrometer by Shirane, Shapiro, and Tranquada, the much broader survey Experimental Neutron Scattering by Willis and Carlile, and with many examples of applications Furrer, Mesot, and Strässle's Neutron Scattering in Condensed

Matter Physics. Of these, the range of material in the book by Willis and Carlile is most similar to that covered in Elements of Slow-Neutron Scattering, but in most instances Carpenter and Loong dive much more deeply into the details of the mathematics and the theory behind the measurements. To this reviewer a real strength of Elements of Slow-Neutron Scattering is that it maintains the rigor of Marshall and Lovesey while conveying a vast amount of information concerning experimental practice.

I expect that Elements of Slow-Neutron Scattering should be in high demand by physicists and other scientists who would like to utilize neutron methods as a significant part of their research program. Professional neutron scatterers, especially those engaged in building or improving instruments, will absolutely want to have this book on their shelves. Students or others seeking a quick overview of the technique may prefer something different, but with proper guidance Elements of Slow-Neutron Scattering will be a useful resource for a graduate level course. The on-line supplemental information is a most interesting innovation. The material might be easier to use if the web-site included a text search feature, but that is a minor quibble. I will definitely recommend this book to students, colleagues, and anyone else with a strong interest in neutron scattering.

Stephen E. Nagler
Oak Ridge National Laboratory

An Introduction to Practical Laboratory Optics by J.F. James, Cambridge University Press, 2014, pp. 196, ISBN: 9781107687936, price: 91.95.

The title of the book conjured up images of having practical labs laid out that could be used in the classroom. That, however, is not what this book is about. The book describes several optical devices and techniques, and is interesting to read. The main text of the book has very few equations, and describes with figures different types of telescopes, binoculars, eyepieces, cameras, charge coupled devices, spectrophotometers, interferometers and microscopes. Most of the descriptions are fairly brief, but should be interesting to someone who has not used a lot of optical equipment. The strength of the book is in its many nice line drawing figures of how the devices work. Equations for Gaussian optics, optical aberrations, and Fourier optics are only presented in appendixes. The equations are presented without any accompanying derivation, and there are no examples provided of their use. The book would probably be most useful to someone who has already taken some optics, and would provide an additional reference describing the many possible devices that one might come across.

Dr. Blair Jamieson
University of Manitoba

Mid-Ocean Ridges by de Roger Searle, Cambridge University Press, 2013, pp. 330, ISBN: 978110701752-8 (hbk), price: 81.95.

Les dorsales médio-océaniques (en anglais “Mid-Ocean Ridges” ou MOR), s’étendent sur plus de 65,000 km à travers le fond océanique, et ce à un endroit crucial où se forme la croûte océanique. L’auteur présente un ouvrage sur le sujet des MORs formés sur la planète en débutant par un bref historique des techniques et études ayant mené à leur découverte, pour mieux ensuite nous nous en exposer la dynamique. Le volume couvre la lithosphère océanique, la structure et la composition de la croûte océanique, les processus hydrothermales et tectoniques associés aux MORs et leur rôle dans la formation des plaques océaniques, à leur frontière.

Le premier chapitre présente une introduction à l’étude des MORs depuis M.F. Maury, la découverte des tectoniques des plaques, pour terminer avec les programmes de recherche plus récents et les institutions intéressées. Le second chapitre est un compte rendu des diverses techniques appliquées au développement des études du fond océanique (méthode géophysique basée sur les propriétés sismiques, gravimétriques, résistance électrique, méthodes utilisant l’écho-sondage et mesure par sonar), ainsi qu’aux techniques modernes d’imagerie, forage et submersible. Le troisième chapitre s’intéresse à la lithosphère océanique et ses propriétés physiques, de même qu’au lien avec l’asthénosphère sous-jacente. Le chapitre suivant place les MORs dans le contexte global de la cinématique des plaques et décrit les particularités du relief au centre de l’étalement. Le chapitre 5 présente la structure et la composition de la croûte océanique; confrontant la vue des géophysiciens et celle des pétrologistes, ainsi que la magnétisation respective des types de roche. Le chapitre 6 porte sur le volcanisme et la morphologie des MORs correspondants et il est suivi du chapitre 7 sur la tectonique des plaques. Le chapitre 8, probablement le plus intéressant, se concentre sur les activités hydrothermales et leurs émanations; décrites dans un contexte autant spatial que temporel. Il y est question notamment de celles présentes dans la crête de Juan de Fuca à 250 km au sud-ouest de l’île de Vancouver. D’ailleurs, une part importante du chapitre porte sur la présentation des formes de vie habitant cet environnement extrême.

Notons le fait important que cet ouvrage est richement illustré de cartes, de graphiques, de données et de tableaux qui facilitent la compréhension pour le non spécialiste; ainsi qu’un repérage rapide permettant de se retrouver et de bien cerner les enjeux relatif au sujet. Un glossaire de terminologie et un dictionnaire des différents MOR utilisés dans le volume permettent constituent une référence utile aux lecteurs. À la fin, une bibliographie détaillée permet d’approfondir les divers sujets abordés. Ce livre s’adresse très bien aux océanographes physiques, mais il pourrait sembler élémentaire pour les géophysiciens travaillant dans ce domaine. C’est vraiment «un plus» de lire cet ouvrage qui amène à se questionner sur ce qui existe sous les océans.

André April
Environnement Canada.

Qu’est-ce que le boson de Higgs mange en hiver et autres détails essentiels by de Pauline Gagnon Éditions MultiMondes, 2015, pp. 200, ISBN: 978-2-89544-409-9, price: 29,95.

Voici un livre coloré et truffé d’analogies pertinentes, par lequel la physicienne Pauline Gagnon, explique à un grand public intéressé, les tenants et aboutissants des expériences menées au grand collisionneur (LHC) du CERN. Plutôt orienté vers une approche expérimentale des connaissances, il constitue une excellente vulgarisation de la physique des particules élémentaires, en relation avec les expériences récentes et à venir à ce prestigieux centre de recherche européen.

Rares sont les pages de ce livre ne contenant pas de photo, d’image ou de graphiques simplement expliqués à un lectorat non spécialisé. Sans l’aide d’équation, mais plutôt au moyen d’exemples et d’analogies forts justes, l’auteure réussit brillamment à présenter simplement les concepts sous-jacents aux théories complexes et prodiges technologiques, relatifs aux expériences ayant conduit à la découverte du boson de Higgs. Sa solide main mise sur l’ensemble des pratiques en physique expérimentale mais aussi, qualité rare, son habileté à les mettre en lien avec les théories qui leurs sont associées, font que ce livre impressionne par l’étendue de son contenu. De plus elle s’adresse à ses lecteurs et lectrices avec respect envers leur capacité d’apprendre : elle introduit la notation scientifique et pose, souvent par des dessins simples, les bases nécessaires à leur compréhension des résultats expérimentaux, présentés dans leur format original.

Le livre se divise en 10 chapitres et comporte 2 annexes. Sept de ces chapitres concernent la physique proprement dite : ils contiennent une vulgarisation de la science nécessaire à la compréhension de l’importance de la découverte du boson de Higgs et une présentation du collisionneur et des détecteurs, en particulier d’ATLAS, sur lequel l’auteure a travaillé. Il aborde aussi les sujets de la matière sombre, des limites du Modèle standard et de la Supersymétrie comme une théorie qui pourrait lui succéder. Enfin le tout dernier chapitre fait entrevoir ce que les prochaines expériences menées au CERN et ailleurs pourraient apporter de nouveau sur le plan scientifique. Les autres chapitres sont une réflexion sur des questions connexes à savoir la raison d’être de la recherche fondamentale, le contexte de travail au CERN et la question de la diversité en physique. Enfin deux annexes sur la présence des femmes en physique complètent ces réflexions.

Vivant et parsemé d’anecdotes amusantes sur les chercheurs et leurs découvertes, le livre de Pauline

Gagnon place son lectorat au cœur des recherches scientifiques actuelles du CERN. Il sera donc des plus profitables aux étudiants et étudiantes du secondaire et du CEGEP tentés par la physique. Les personnes préoccupées par la situation des femmes ou la diversité en physique y trouveront aussi des données pertinentes.

En conclusion, je recommande fortement ce livre à toute personne intéressée par la physique des particules et prête à faire l'effort nécessaire pour assimiler des connaissances très actuelles vulgarisées de mains de maître.

Luce Gauthier PhD, physicienne retraitée

STATISTICS AND ANALYSIS OF SCIENTIFIC DATA
Edited by Bonamente Massimiliano, Springer, 2013, pp. 320, ISBN: 9781461479840, price: 99.00.

Ce livre couvre les fondements de la théorie des probabilités et de la statistique en plus de présenter des méthodes pour l'analyse des données scientifiques. Pour être en mesure de lire ce livre, il faut connaître le calcul différentiel et intégral, mais aucune connaissance particulière des probabilités et des statistiques n'est requise. Un étudiant au baccalauréat en physique pourrait donc être capable de le comprendre. Toutefois, étant donné qu'il a été publié dans la série «Graduate Texts in Physics», l'ouvrage s'adresse probablement davantage aux étudiants débutant leur maîtrise ou leur doctorat. L'auteur mentionne d'ailleurs avoir rédigé le livre sur une période de 10 ans alors qu'il développait un cours gradué à la University of Alabama. Il peut également servir de référence à des scientifiques s'intéressant au domaine.

Par rapport à d'autres livres couvrant seulement les statistiques, les probabilités ou encore les méthodes d'analyse spécialisées pour une science particulière, cet ouvrage se veut un assemblage du tout. On s'attarde ainsi à des techniques pouvant être utilisées dans divers champs d'expertise : astronomie, biologie, sciences administratives, chimie, génie et physique. L'approche pédagogique utilisée consiste en la présentation de la théorie, souvent suivie par un exemple numérique pour aider à comprendre la matière. Fait intéressant, pour illustrer les méthodes, l'auteur réfère entre autres aux données de différentes expériences fondamentales des siècles précédents. À titre d'exemple, on aborde la découverte de l'électron au moyen de l'expérience de J.J. Thompson ou encore l'expansion de l'univers avec les observations faites par E. Hubble. Le livre contient également quelques problèmes théoriques et numériques à la fin de chaque chapitre avec des solutions en annexe.

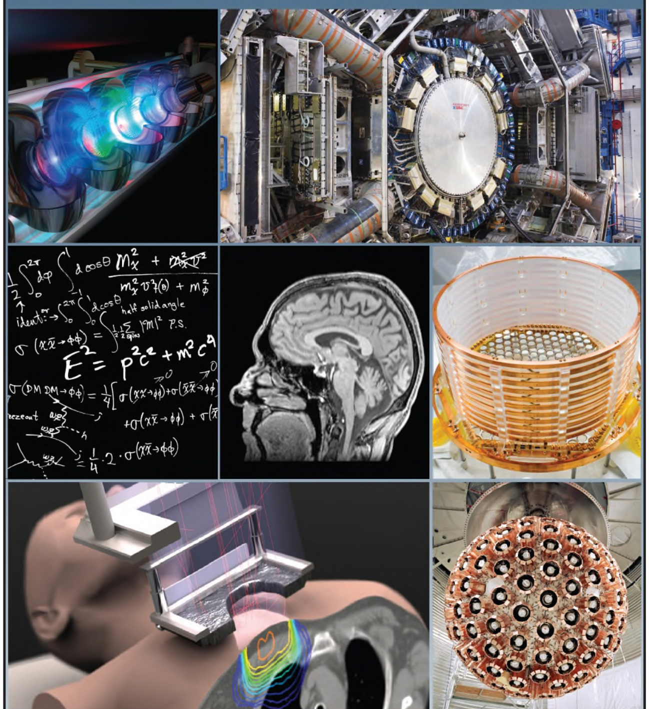
L'ouvrage se divise en 10 chapitres. Le premier chapitre porte sur la théorie des probabilités. Dans les deux chapitres suivants, on s'attarde aux variables aléatoires, à leur distribution (e.g. binomiale, Gaussienne et Poisson) et aux fonctions de variables aléatoires. On y présente aussi le théorème de la limite centrale et la loi des grands nombres. Au chapitre 4, on s'intéresse à la moyenne, la variance et les intervalles de confiances. L'étude des tests statistiques (e.g. test du χ^2) suivra au chapitre 5. Les trois prochains chapitres portent respectivement sur l'ajustement de fonctions à deux variables, l'analyse permettant de déterminer si le modèle utilisé pour l'ajustement est adéquat ou non et, enfin, la comparaison de différents modèles. Les deux derniers chapitres concernent les méthodes Monte Carlo et les chaînes de Markov ainsi que les chaînes de Monte Carlo Markov. Le livre se termine avec environ 70 pages d'annexe incluant plusieurs tableaux.

En résumé, il s'agit certainement d'une bonne ressource pour des étudiants sous-gradués ou gradués, et même pour des chercheurs bien établis, maîtrisant le calcul différentiel et intégral, sans posséder nécessairement de connaissances en statistiques. Le livre ne traite évidemment pas de toutes les techniques utilisées en statistique car les auteurs ont choisi de se limiter aux techniques applicables à un certain nombre de disciplines.

Léo Barriault

CARLETON UNIVERSITY

DEPARTMENT OF PHYSICS



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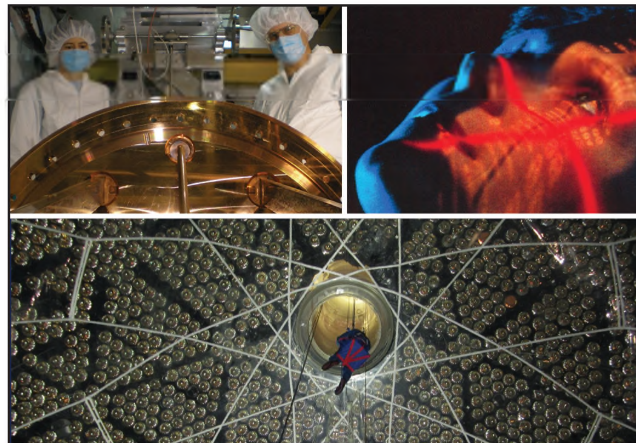

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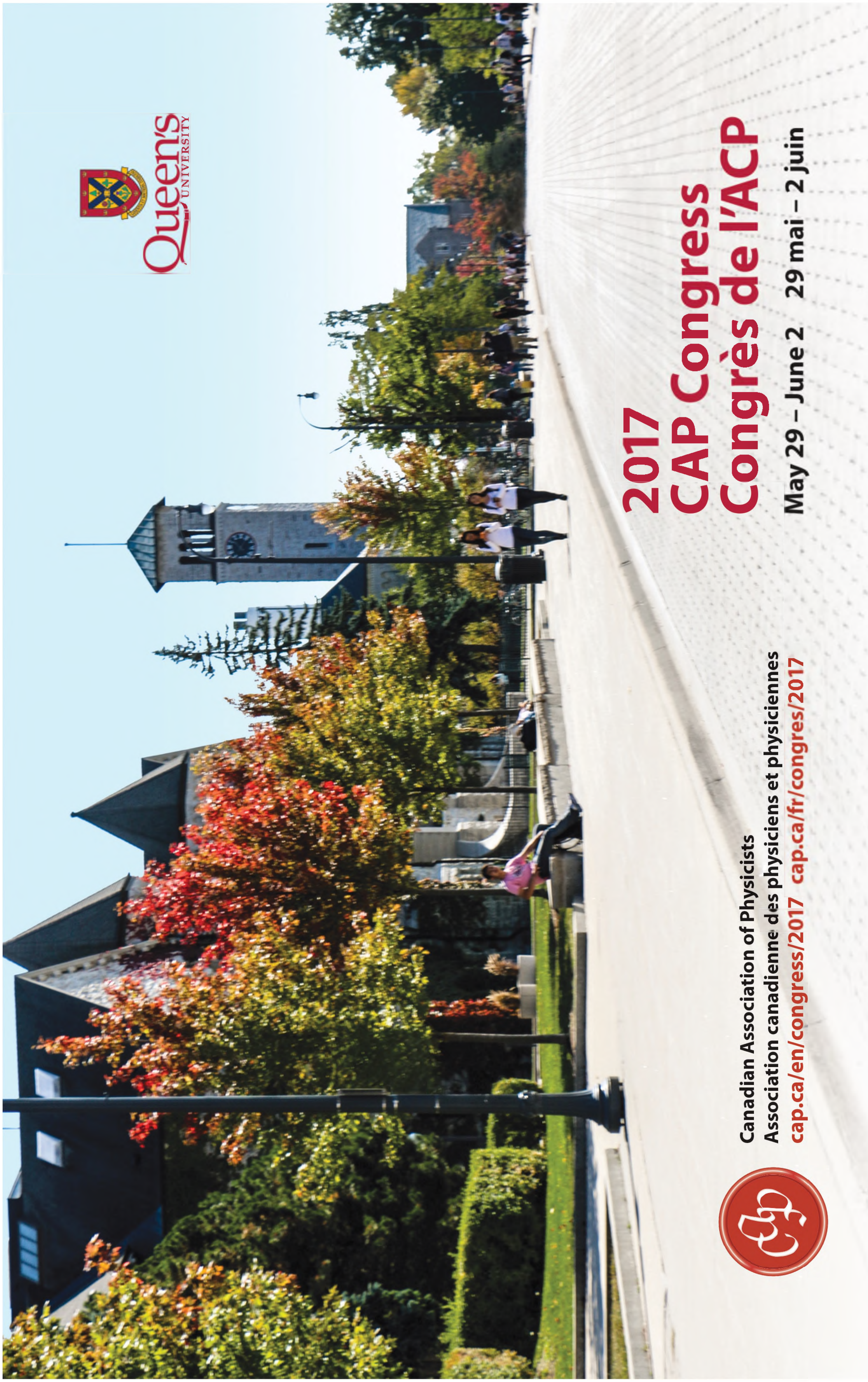

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