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Physics in Canada
La Physique au Canada

Physics Outreach / *L'engagement communautaire de la physique*

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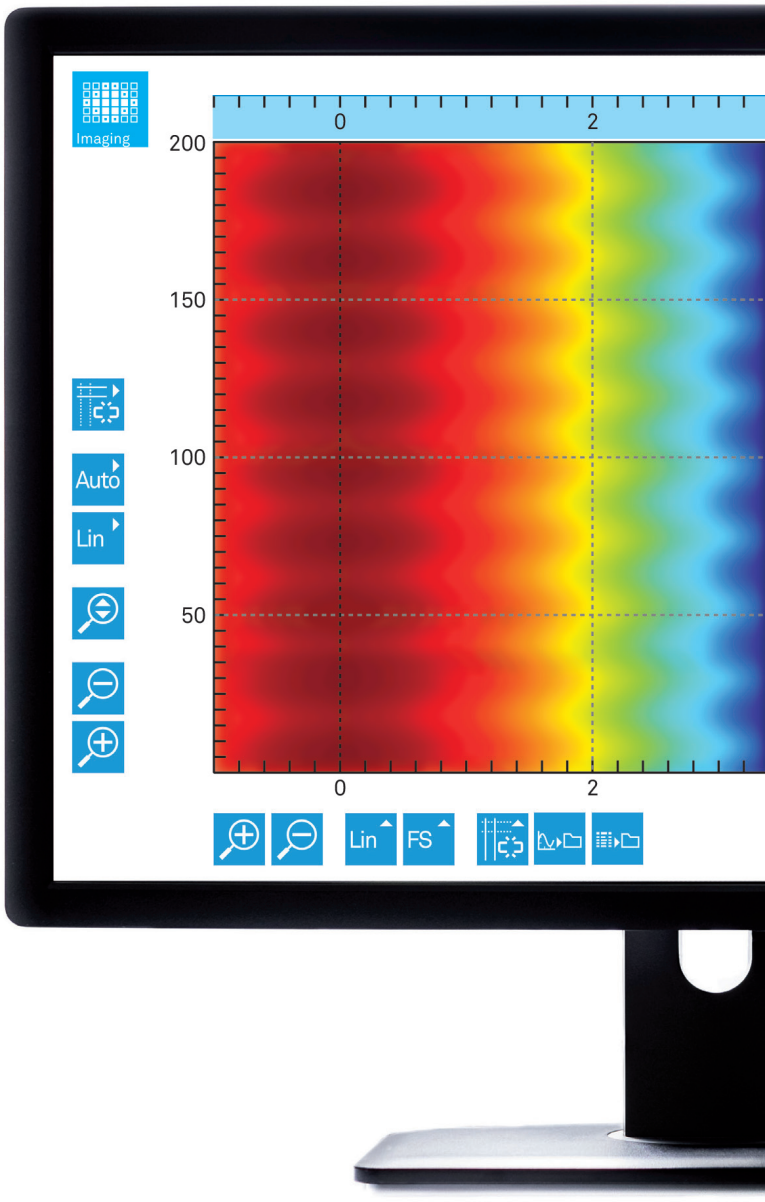

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Cover / Couverture :

Participants in the Fall 2014 Girls Exploring Physics workshop at Simon Fraser University engaged in a hands-on particle physics activity. Photo courtesy of Dale Northey/SFU Creative Studio.

Participantes à l'atelier «Girls Exploring Physics» à l'Université Simon Fraser durant l'automne 2014, qui prennent part à une activité pratique sur la physique des particules. Photo courtoisie de Dale Northey/SFU Creative Studio.

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Canadian Association of Physicists (CAP)
Association canadienne des physiciens et physiciennes (ACP)

The Canadian Association of Physicists was founded in 1945 as a non-profit association representing the interests of Canadian physicists. The CAP is a broadly-based national network of physicists working in Canadian educational, industrial, and research settings. We are a strong and effective advocacy group for support of, and excellence in, physics research and education. We represent the voice of Canadian physicists to government, granting agencies, and many international scientific societies. We are an enthusiastic sponsor of events and activities promoting Canadian physics and physicists, including the CAP's annual congress and national physics journal. We are proud to offer and continually enhance our web site as a key resource for individuals pursuing careers in physics and physics education. Details of the many activities of the Association can be found at http://www.cap.ca. Membership application forms are also available in the membership section of that website.

L'Association canadienne des physiciens et physiciennes a été fondée en 1946 comme une association à but non-lucratif représentant les intérêts des physicien(ne)s canadien(ne)s. L'ACP est un vaste regroupement de physiciens oeuvrant dans les milieux canadiens de l'éducation, de l'industrie et de la recherche. Nous constituons un groupe de pression solide et efficace, ayant pour objectif le soutien de la recherche et de l'éducation en physique, et leur excellence. Nous sommes le porte-parole des physiciens canadiens face au gouvernement, aux organismes subventionnaires et à plusieurs sociétés scientifiques internationales. Nous nous faisons le promoteur enthousiaste d'événements et d'activités mettant à l'avant-scène la physique et les physiciens canadiens, en particulier le congrès annuel et la revue de l'Association. Nous sommes fiers d'offrir et de développer continuellement notre site Web pour en faire une ressource clé pour ceux qui poursuivent leur carrière en physique et dans l'enseignement de la physique. Vous pouvez trouver les renseignements concernant les nombreuses activités de l'ACP à http://www.cap.ca. Les formulaires d'adhésion sont aussi disponibles dans la rubrique «Adhésion» sur ce site.

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PHYSICS OUTREACH

We live in a society exquisitely dependent on science and technology, in which hardly anyone knows anything about science and technology.
Carl Sagan

The debate about the role of science in modern society, the funding of basic research, and the future of science is not new [1]. Exactly 150 years after its founding, Canada finds itself at the proverbial "science and technology crossroads". We, as a society, have to decide if our country is going to be amongst the world's science leaders and innovators, or are we going to keep relying on our natural resources and become consumers of the science discoveries and technological innovations produced by others? Today, science funding and especially basic research funding in Canada is under continuous threat and it does not look like the situation is going to improve in the near future. As was pointed out in the March 2017 news release by the Canadian Association of Physicists (CAP), the proposed 2017 Federal Budget allocates little new spending for science in the upcoming year [2]. While the Budget attempts to emphasize innovation and a technology-driven economy, it is unclear how this goal can be achieved without a significant increase in support for fundamental research and for educating the next generation of Canadians who are interested in pursuing scientifically-oriented careers [3].

Inadequate funding for basic research and the lack of engagement by Canadian scientists in our political system have significant implications not only for the Canadian science community, but for our economy, healthcare system, and Canadian society at large. Therefore, there is an urgent need for scientists to communicate their work to the general public in a comprehensible and engaging way, so lay people (including most Canadian politicians) can understand and appreciate the contributions of science to our society and the ever-increasing role science plays in our lives. Interestingly, one of the greatest scientists in the history of physics, Michael Faraday (1791-1867) realized this almost 200 years ago. In 1825 Faraday established the Royal Institution Christmas Lectures that have continued to be held annually except during the Second World War. Michael Faraday hosted 19 of these lectures and many other notable scientists followed in his footsteps. However, despite the increasing role of science and technology in our society and an increasing ability to watch lectures given by world-class scientists and popularizers of science, such as George Gamow, Richard Feynman, Carl Sagan, Stephen Hawking, Michio Kaku, Lawrence Krauss or Brian Green, online, the general public in Canada is by and large disengaged if not alienated from science.

It is somewhat paradoxical that the more we as a society become dependent on the results of fundamental scientific discoveries (such as the general and special theories of relativity, quantum mechanics, atomic and nuclear physics), the less we are interested in and appreciative of science as an intellectual endeavour. This can be seen from the growing disengagement of Canadian youth from science, technology, engineering and mathematics (STEM) subjects and careers [4,5]. Similar trends are happening in other countries [6-9]. The problem of youth disengagement from STEM is so widespread that a number of governmental education agencies all across the world have attempted to address it by introducing new and often innovative STEM curricula [10-12] or inviting foreign scientifically-oriented skilled workers to do the jobs that that country's citizens are not capable of doing [13]. For example, the focus of the new science curricula in British Columbia is on big ideas in science, the interplay between STEM fields, and applications of STEM to students' lives. However, changing science curricula or educating better science teachers will not solve the problem, unless we also attempt to engage the wider population in science. For example, there is ample evidence that parents have an important influence on students' engagement with STEM [14-16]. Therefore, if we want to change society's attitudes about science and its value in modern society, we should consider how to engage parents in science as well as their children [14,15,17,18].

Considering the challenges of the graying population and the need for highly skilled workers facing Canada, it should not come as a surprise that the 2017 Federal Budget also proposes "new funding to help Canadians prepare for the economy of tomorrow by promoting the development of STEM skills and digital literacy, particularly for women, girls and underrepresented groups" [3]. This is a

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clear statement that in order to be competitive on the world stage, Canada needs to engage a wider share of its population in STEM fields. This can be done by increasing the emphasis on STEM outreach to the general public and scientists' engagement in this outreach.

As the CEO of the American Association for the Advancement of Science, Rush Holt eloquently stated during the *Science Policy in the 21st century* session of the American Physical Society (APS) April meeting 2017 in Washington D.C.: "Science is not just for scientists" [19]. This is as true for Canada as it is for our southern neighbour or any other country for that matter. Science engagement should not be limited to formal educational settings, such as studying STEM subjects in K-12 schools. Science, like art, sports and music, should have a place in the lives of young and old, of students and their parents, of poets and of future prime ministers [20]. Science outreach should play a prominent role in this process [21].

Engaging all Canadians in STEM requires a consorted effort from universities, science research organizations, schools, museums, businesses, non-profit organizations and governmental agencies. The first step in increasing the engagement of Canadians in science is to acknowledge and consolidate public outreach initiatives that are already happening across Canada. Therefore, this special issue on science outreach in Canada is especially timely. We have invited scientists and science educators from all across the country to share public outreach activities they are involved in with the hope that their experiences can be adopted and adapted across the country. This way we will be able to learn from each other, exchange ideas and share experiences in order to build a more innovative, scientifically literate and prosperous Canada.

This issue includes 13 papers outlining various STEM outreach activities across the country. Theresa Liao and her collaborators from the University of British Columbia (UBC) Department of Physics and Astronomy report on the annual UBC Physics Olympics for secondary students that will celebrate its 40th anniversary next year. Marina Milner-Bolotin and her team from UBC Faculty of Education report on the Family Math and Science Day that engages future elementary and secondary teachers in STEM outreach to the general public. Stuart Shepherd and his collaborators from TRIUMF describe a special initiative – the IsoSiM Program - that trains the next generation of science leaders by providing rich and diverse experiences to graduate students in the production and application of radioisotopes. Sarah Johnson from Simon Fraser University in Burnaby reports on a semi-annual workshop series designed to encourage more young women to consider physics as a career path. Tracy Walker and her collaborators from the Canadian Light Source in Saskatoon describe educational programming for secondary students focused on promoting scientific inquiry and inspiring future scientists. Chitra Rangan at the University of Windsor shares a science outreach event, called Phunky Physics, that aims to provide experiential learning opportunities for undergraduate and graduate students and promote science communication to the general public. Martin Laforest and the Communication and Strategic Initiatives team from the Institute for Quantum Computing at the University of Waterloo describe workshops they developed for students and teachers. They also outline a travelling museum exhibition built to raise awareness about quantum mechanics and quantum technologies. Shohini Ghose and her collaborators from Wilfrid Laurier University share a story of a very creative and innovative collaboration between the arts and the sciences – a provocative photo-research exhibit on sexism and science. Joanne O'Meara from the University of Guelph describes a new initiative where undergraduate physics students are required to take the Physics Communication course and learn how to share their passion for physics with different audiences. Graham Pearson from Ryerson University Department of Physics reports on an outreach program designed to promote the field of medical physics to secondary students and to the general public in the Greater Toronto Area. The scale of the event described by Kelsey Miller – an Executive Director of Science Rendezvous – is very impressive. Science Rendezvous is the largest STEM outreach event in the country, annually reaching more than 300,000 visitors across all Canadian provinces and territories. In her paper she describes how a team of scientists and engineers, in the public and private sectors, as well as students and educators, has built a large-scale collaborative outreach event and what they have been able to achieve in the last decade. Lastly, Miriam Hewlett and her collaborators from Acadia University describe a different approach to high school outreach by post-secondary students. Their outreach effort was focussed especially on female high-school students in order to inspire them to pursue STEM post-secondary education.

As one can see from the selection of outreach initiatives outlined above, we did not try to make a survey of all public outreach in science happening across the country. Rather, we attempted to introduce the readers to some of these initiatives, especially programs with a physics focus, with the hope that scientists, science educators and educational leaders all across Canada might find an outreach activity that will inspire them to organize a similar event at their institution or in their community. While there is no universal recipe for successful science outreach, there are common elements that make these events memorable and successful: informative and entertaining science activities, clear and jargon-free science communication, an ability to engage the audience, and an openness to positive interactions between scientists and the general public. We also attempted to illustrate the benefit of science outreach activities for the people who facilitate them - undergraduate and graduate students, faculty members and research staff, as well as future teachers. We hope this special issue will illustrate the value of science outreach for the outreach providers, as well as for the general public.

We hope this issue will inspire more exciting STEM outreach activities across Canada. If, as a result of reading the papers in this issue, the readers decide to communicate with some of the authors with the goal of learning more about these exciting initiatives in order to organize similar events at their institutions, we know we have achieved our goal.

Marina Milner-Bolotin, University of British Columbia
Sarah Johnson, Simon Fraser University
Guest Editors, *Physics in Canada*

Comments of readers on this editorial and this issue are more than welcome.

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L'engagement communautaire de la physique

Nous vivons dans un monde qui dépend au plus haut point de la science et de la technologie et où personne ne sait vraiment rien de la science et de la technologie.

Carl Sagan

Il n'est pas nouveau le débat entourant le rôle de la science dans le monde moderne, le financement de la recherche fondamentale et l'avenir de la science [1]. Exactement 150 ans après sa fondation, le Canada se retrouve à la proverbiale « croisée de la science et de la technologie ». En tant que société, il nous faut décider si notre pays se hissera parmi les meneurs et innovateurs mondiaux en science ou bien s'il continuera de miser sur ses ressources naturelles, se contentant de gober les découvertes scientifiques et les innovations technologiques des autres. Aujourd'hui, le financement de la science, et notamment celui de la recherche fondamentale au Canada, est constamment menacé et la situation ne semble pas devoir bientôt s'améliorer. Comme le mentionnait l'Association canadienne des physiciens et physiciennes (ACP) dans son communiqué de mars dernier, le budget fédéral 2017 proposé alloue peu d'argent frais à la science pour la prochaine année [2]. Il vise à faire valoir l'innovation et l'économie fondée sur la technologie, mais la façon d'atteindre cet objectif n'est pas évidente sans un appui nettement plus fort à la recherche fondamentale et à l'éducation de la prochaine génération de Canadiens que la poursuite de carrières d'orientation scientifique intéresse [3].

Le financement insuffisant de la recherche fondamentale et le peu d'engagement des scientifiques canadiens dans notre système politique ont de profondes incidences non seulement sur la collectivité scientifique canadienne, mais aussi sur notre économie, notre système de santé et l'ensemble de la société canadienne. Il est donc impérieux que les scientifiques communiquent leurs travaux au grand public de façon compréhensible et engageante afin que les profanes (dont la plupart des politiciens canadiens) puissent saisir et apprécier l'apport de la science à notre société et le rôle de plus en plus grand de la science dans nos vies. Fait intéressant à noter, l'un des plus grands scientifiques de l'histoire de la physique, Michael Faraday (1791-1867), l'a compris il y a près de 200 ans. En 1825, il a créé les conférences de Noël (Christmas Lectures) de la Royal Institution qui ont eu lieu tous les ans sauf pendant la Seconde Guerre mondiale. Il a tenu 19 de ces conférences, et bien d'autres scientifiques renommés l'ont imité. Cependant, en dépit du rôle de plus en plus grand de la science et de la technologie dans notre monde et des possibilités croissantes d'entendre ces conférences données en ligne par des scientifiques de classe mondiale et des vulgarisateurs scientifiques tels George Gamow, Richard Feynman, Carl Sagan, Stephen Hawking, Michio Kaku, Lawrence Krauss et Brian Green, le grand public canadien se sent dans l'ensemble désengagé, sinon aliéné, face à la science.

Il est quelque peu paradoxal que plus nous devenons dépendants des résultats des découvertes en science fondamentale (telles les théories générale et spéciale de la relativité, la mécanique quantique, la physique atomique et nucléaire) en tant que société, moins nous apprécions la science et y voyons une activité intellectuelle intéressante. Cela se voit par le désengagement croissant des jeunes Canadiens à l'égard des matières et carrières en science, technologie, ingénierie et mathématiques (STIM) [4, 5]. Des tendances semblables se dessinent dans d'autres pays [6-9]. Le problème que pose le désenchantement des jeunes face aux STIM est si répandu que divers organismes gouvernementaux d'éducation du monde entier ont tenté de le régler en instituant des programmes de STIM nouveaux et souvent novateurs [10-12] ou en invitant des travailleurs qualifiés étrangers, axés sur les sciences, à occuper les emplois que les citoyens d'ici sont incapables d'exercer [13]. Par exemple, les programmes de science de la Colombie-Britannique mettent l'accent sur les grandes idées de cette discipline, l'interaction entre les domaines des STIM et leur application dans la vie des étudiants. Cependant, changer les programmes de science ou former de meilleurs enseignants dans cette discipline ne réglera pas le problème, à moins de tenter par ailleurs d'engager l'ensemble de la population à l'égard des sciences. Par exemple, il y a amplement de preuves que les parents influencent fortement l'engagement des étudiants à l'égard des STIM [14-16]. Aussi, si nous voulons changer les attitudes de la société face à la science et à sa valeur dans la société moderne, nous devrions examiner comment engager les parents, et leurs enfants, face à la science [14, 15, 17, 18].

Devant les défis de la population vieillissante et les travailleurs hautement qualifiés dont a besoin le Canada, il ne devrait pas surprendre que le budget fédéral de 2017 propose en outre « de nouveaux fonds pour aider les Canadiens à se préparer à l'économie de demain en favorisant le perfectionnement des compétences en science, en technologie, en ingénierie et en mathématiques (STIM), ainsi qu'en littératie numérique, plus particulièrement en ce qui concerne les femmes, les filles et les groupes sous-représentés [3] ». Il en ressort clairement que, si le Canada veut être compétitif sur la scène mondiale, il doit engager une part plus grande de sa population dans les domaines des STIM. Cela est possible en mettant davantage l'accent sur la sensibilisation du grand public aux STIM et sur l'engagement des scientifiques à cet égard.

Comme l'a affirmé avec éloquence le directeur général de l'Association américaine pour le progrès de la science, Rush Holt, durant la séance *Science Policy in the 21st century* tenue en avril 2017 par l'American Physical Society (APS) à Washington D.C., « la science n'est pas seulement pour les scientifiques [19] ». Cela vaut autant pour le Canada que pour notre voisin du Sud ou tout autre pays à cet égard. L'engagement à l'égard de la science ne doit pas se limiter aux cadres d'éducation officiels, telle l'étude des matières STIM de la maternelle à la 12e année. Tout comme les arts, les sports et la musique, la science doit avoir une place dans la vie des jeunes et moins jeunes, des étudiants et de leurs parents, des poètes et des futurs premiers ministres [20]. La sensibilisation aux sciences devrait jouer un rôle de premier plan dans ce processus [21].

Pour engager tous les Canadiens dans les STIM, il faut un effort concerté des universités, organismes de recherche scientifique, écoles, musées, entreprises, organismes sans but lucratif et organismes gouvernementaux. La première étape pour engager les Canadiens à l'égard de la science est de déterminer et consolider les initiatives publiques de sensibilisation déjà en place dans tout le Canada. Ce numéro spécial sur la sensibilisation aux sciences au Canada arrive donc à point nommé. Nous avons invité des scientifiques et des enseignants en science du pays tout entier à mettre en commun les activités de sensibilisation auxquelles ils participent dans l'espoir que leurs expériences puissent être adaptées et adoptées dans tout le pays. Ainsi, nous pourrons apprendre les uns des autres, échanger des idées et partager des expériences afin de bâtir un Canada plus innovateur, éduqué scientifiquement et prospère.

Le présent numéro contient 12 documents décrivant diverses activités de sensibilisation aux STIM dans tout le pays et un rapport à propos de la 6ième conférence internationale de l'IUPAP pour les femmes en physique. Theresa Liao et ses collaborateurs du Département de physique et d'astronomie de l'Université de la Colombie-Britannique (UBC) font état du concours annuel de physique (Physics Olympics) que tient l'UBC pour les étudiants du secondaire, pour célébrer son 40e anniversaire l'an prochain. Marina Milner-Bolotin et son équipe de la Faculté d'éducation de l'UBC font état de la journée familiale des maths et des sciences qui incite les futurs enseignants des niveaux primaire et secondaire à sensibiliser le grand public aux STIM. Stuart Shepherd et ses collaborateurs de TRIUMF décrivent une initiative spéciale – le programme IsoSiM - qui vise à former la prochaine génération de leaders scientifiques en procurant aux étudiants diplômés des expériences diverses et enrichissantes de production et d'application de radioisotopes. Sarah Johnson de l'Université Simon Fraser, à Burnaby, fait état d'une série d'ateliers semestriels qui vise à encourager davantage de jeunes femmes à envisager un cheminement de carrière en physique. Tracy Walker et ses collaborateurs du Centre canadien de rayonnement synchrotron à Saskatoon décrivent un programme d'enseignement aux étudiants du secondaire, qui est axé sur la promotion de la recherche scientifique et l'inspiration des futurs scientifiques. Chitra Rangan, à l'Université de Windsor, partage une activité de sensibilisation aux sciences appelée Phunky Physics (physique branchée), qui vise à donner aux étudiants du premier cycle et des cycles supérieurs des possibilités d'apprentissage, et à promouvoir la communication scientifique au grand public. Martin Laforest et l'équipe des initiatives stratégiques et de communication de l'Institut d'informatique quantique de l'Université de Waterloo décrivent des ateliers mis sur pied pour les étudiants et les enseignants. Ils font aussi état d'une exposition muséale itinérante qui vise à sensibiliser à la mécanique et aux technologies quantiques. Shohini Ghose et ses collaborateurs de l'Université Wilfrid-Laurier racontent l'histoire d'une collaboration très créatrice et novatrice entre les arts et les sciences – une exposition-recherche de photos sur le sexisme et la science. Jo-Anne O'Meara de l'Université de Guelph décrit une nouvelle initiative qui oblige les étudiants du premier cycle en physique à suivre le cours de communication dans cette discipline et à apprendre comment partager leur passion pour celle-ci à différents auditoires. Graham Pearson, du Département de physique de l'Université Ryerson, fait état d'un programme de sensibilisation conçu pour promouvoir le domaine de la physique médicale auprès des étudiants du secondaire et du grand public de la région du Grand Toronto. L'envergure de l'événement décrit par Kelsey Miller – directrice générale de Science Rendezvous – est fort impressionnante. Cette activité de sensibilisation aux STIM, la plus vaste au pays, atteint chaque année plus de 300 000 visiteurs de l'ensemble des provinces et territoires canadiens. L'article de Kelsey Miller décrit comment une équipe de scientifiques et d'ingénieurs des secteurs public et privé, ainsi que d'étudiants et d'enseignants, a mis sur pied une activité de sensibilisation collaborative de grande envergure, et ce qu'elle a pu réaliser au fil de la dernière décennie. Enfin, Miriam Hewlett et ses collaborateurs de l'Université Acadia décrivent une méthode différente de sensibilisation des étudiants du secondaire par des étudiants au postsecondaire. Leur effort de sensibilisation visait notamment les étudiantes du secondaire afin de les inciter à poursuivre l'apprentissage des STIM après leur cours.

Comme le montre l'envergure des initiatives de sensibilisation décrites ci-dessus, nous n'avons pas cherché à inventorier tout ce qui se passe à l'échelle du pays en matière de sensibilisation du public aux sciences. Nous avons plutôt tenté de faire connaître certaines de ces initiatives aux lecteurs, notamment les programmes mettant l'accent sur la physique, dans l'espoir que scientifiques, enseignants en science et leaders du Canada tout entier en enseignement puissent trouver une activité de sensibilisation qui les incite à en organiser de semblables dans leur établissement ou leur collectivité. Il n'y a pas de modèle universel de sensibilisation fructueuse aux sciences, mais ces activités comportent des éléments communs qui les rendent mémorables et

fructueuses : le caractère informatif et agréable en science, un langage clair et sans jargon technique, la capacité d'engager l'auditoire et l'ouverture aux interactions positives entre les scientifiques et le grand public.

Après avoir lu les articles de ce numéro, si le lecteur décide de communiquer avec certains auteurs pour en savoir plus long sur ces initiatives passionnantes, nous saurons que nous avons atteint notre but.

Marina Milner-Bolotin, Université de la Colombie-Britannique
Sarah Johnson, Université Simon Fraser
Rédactrices honoraires, *La Physique au Canada*.

Les commentaires de nos lecteurs (ou) lectrices au sujet de cette préface sont les bienvenus.

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

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Four Decades of High School Physics Olympics Competitions at the University of British Columbia

by Theresa Liao, Janis McKenna, and Marina Milner-Bolotin

University of British Columbia (UBC) Physics Olympics is a high school physics competition held annually at UBC in Vancouver. This annual outreach event attracts over 450 high school students, competing in teams, and over 55 teachers/coaches from across the province. This competition, organized by the Department of Physics and Astronomy and the Department of Curriculum and Pedagogy at UBC, is one of the largest and oldest high school physics competitions of its kind in North America.

The competition consists of six hands-on events (heats), of which two are pre-built by the students in the months before the competition. In recent years, it also included professional development workshops and networking opportunities for physics teachers/coaches who accompany the teams to the competition.

Fig. 1 Student volunteers from the 2016 UBC Physics Olympics.

PARTICIPATION

Each school may enter one student team, which participates in all 6 events. A team may have a maximum of 15 registered students, of which at most 5 can participate in a given event. Events are designed so undersized teams are not penalized. Each event is run and judged by a UBC faculty member assisted by 5-10 undergraduate and graduate students, in 6 one-hour heats.

Summary

More than 450 BC students participate annually in UBC Physics Olympics - one of the largest and oldest high school physics competitions in North America.

Key words: hands-on science, high school physics, physics competition, pre-built activities, Science Technology Engineering and Mathematics (STEM), STEM outreach.

We receive about 60 registrations annually from all across BC, as far as Terrace [1], Mackenzie [2], and Invermere [2], [3] (1360 km, 970 km and 840 km driving distance from UBC respectively).

PROGRAM DEVELOPMENT

Over 60 UBC students and 10 faculty members (Fig. 1) volunteer for the event annually. The heats are designed, prototyped and tested beginning in autumn, with some of the ideas originating from the undergraduate and graduate student volunteers. The program's success in attracting excellent students to UBC is reflected in its volunteer composition: about 50% of our volunteers for the event participated in Physics Olympics while they were in high school. The focus of the activities is on the understanding and utilization of physics principles, and not the ability to engineer devices or quickly solve standard physics problems.

UBC PHYSICS OLYMPICS EVENTS

For the past decade, the Competition has consisted of six heats: two pre-builts, two lab-based and two

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Fig. 2 Examples of students' pre-built projects.

Fig. 3 Final Quizzics at the end of Physics Olympics.

knowledge-based events. Rules and the Rule Books from the past 24 years may be found on the Physics Olympics website http://physoly.phas.ubc.ca/ [4].

Pre-Build Events: Two events require structures pre-built by the students in the month preceding the competition. Students design and construct an apparatus to perform a very specific task, satisfying rules on materials and construction (Fig. 2). For example, past pre-build events include design & construction of a device that:

- displaces the maximum amount of water when dropped in a filled bucket.
- elevates a golf ball by 50 cm in the minimum amount of time, using only the energy stored in a standard mousetrap.
- sustains circular orbital motion of a weight on a string for the longest possible time, using only gravitational potential energy from the descent of weights.

Laboratory-Based Events: Two lab-based events involve hands-on work with apparatus. Students are informed of the two general topics in advance, and receive details on the day. Past laboratory events included manipulating a 7-segment display using given circuit elements; building a pendulum with specific properties; determining the volume of irregular shapes using buoyancy concepts; figuring out the drag forces on a marble falling inside a container with viscous fluid; matching given position-time and velocity-time graphs using motion detectors, etc.

Knowledge-Based Events: One event consists of Fermi Questions, and the other is "Quizzics", physics questions in a game-show format in which teams work together to solve and answer physics/astronomy questions and problems. The highlight event of the day brings all student competitors together for the exciting Quizzics championship, in which top teams compete in a gameshow tournament just before the award ceremony (Fig. 3).

PROFESSIONAL DEVELOPMENT FOR HIGH SCHOOL TEACHERS

In recent years, a faculty member in the Faculty of Education has organized professional development workshops for the benefit of the teachers/coaches who volunteer their time helping students prepare for the Physics Olympics, and accompany them on the trip to UBC.

AWARDS

Gold, Silver and Bronze medals are awarded to the members of the top 3 teams in each of the 6 events. Each of the top 6 schools in the overall competition receives an engraved plaque to keep in their school; the top team overall gets possession of the grand traveling trophy for the year.

CONCLUSION

In 2018, UBC Physics Olympics will celebrate its 40th anniversary. It has become one of the best known outreach events run by UBC Departments of Physics & Astronomy and Curriculum and Pedagogy. The positive feedback from the teachers, students and parents underscores the impact of the event on the community. In the words of one of the teachers (Mrs. Shirley Frykberg, used with permission):

> *Events such as Physics Olympics provides our students with many opportunities […] working in a team, across grades outside of the classroom, exposure to competition in a university setting, meeting like-minded students from other schools and towns, extending their math and physics skills beyond the curriculum, honing their critical thinking skills […] It actually is fantastic what a one day event can provide to boost a student's interest and confidence in physics...*
>
> *For teachers this is a great opportunity to network beyond our busy schedules and to discuss and share ideas with each other. Having the common room for teachers to meet as well as the professional development opportunity is an excellent idea.*

[...] I also enjoyed hanging out with our students for the day, getting to know them and sharing the joy in their success.

Events such as UBC Physics Olympics emphasize the value of collaboration between the Faculties of Science and Education in order to engage students in meaningful and creative physics activities.

ACKNOWLEDGEMENTS

Numerous people have contributed to the success of the UBC Physics Olympics over four decades. They include: Tom Mattison, Marina Milner-Bolotin, Theresa Liao, Kristin Schleich, Don Witt, Reginald Wild, Samson Nashon, Michael Crooks, Janice Woodrow, Ian Affleck, Mike Hasinoff, Andrzej Kotlicki, Jaymie Matthews, Janis McKenna, Valery Milner, and Chris Waltham. Undergraduate and graduate student volunteers' contributions are equally critical.

The UBC Physics Olympics is organized jointly by the UBC Department of Curriculum and Pedagogy, Faculty of Education, and the Department of Physics and Astronomy, Faculty of Science (Vancouver Campus). Partially supported by the Rex Broughton Memorial Fund, UBC's Physics and Astronomy Outreach, & an NSERC PromoScience Grant.

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FAMILY MATHEMATICS AND SCIENCE DAY AT UBC FACULTY OF EDUCATION

BY MARINA MILNER-BOLOTIN AND VALERY MILNER

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Despite the continuous efforts of provincial governments to revise and improve science, technology, engineering and mathematics (STEM) K-12 education, the performance of Canada's youth on international assessments, such as PISA, is gradually declining [1,2]. Moreover, many Canadian youth turn away from STEM subjects in secondary schools, thus closing doors to exciting and economically viable future career opportunities [3]. At the same time, there is ample evidence that student attitudes about STEM and their decisions to pursue STEM-related careers are shaped well before they enter post-secondary classrooms [4]. Parents and teachers play an important role in shaping student views about STEM-related fields and STEM-related careers [5, 6]. Yet many Canadian Teacher Education programs continue to produce elementary and middle school teachers who have very limited STEM knowledge and who often hold rather negative attitudes about STEM [7]. This report discusses an initiative at the University of British Columbia (UBC) that aims to engage future K-12 teachers in STEM outreach during their teacher education, thus helping them acquire positive attitudes about STEM while at the same time acquiring important STEM outreach experience.

FAMILY MATHEMATICS AND SCIENCE DAY AT UBC FACULTY OF EDUCATION

The goal of this family-oriented one-day weekend event is to engage future K-12 teachers in STEM outreach through designing and leading hands-on STEM activities for the general public. Considering that very few of the non-STEM teacher-candidates have earned an undergraduate STEM degree, their STEM preparation is likely to be rather limited. As a result, many British Columbia K-9 teachers struggle to engage their students in meaningful STEM learning. In order to support teacher-candidates in acquiring positive attitudes about STEM and learning how to engage children and their families in informal STEM education, in 2010 we founded the UBC Faculty of Education Family Mathematics and Science Day [8].

SUMMARY

Family Mathematics and Science Day is a public outreach event run by faculty members and teacher-candidates at UBC Faculty of Education.

Key words: Science Technology Engineering and Mathematics (STEM), STEM attitudes, outreach, teacher education.

The organization of the event begins months in advance and consists of five stages: (1) The time, location and the program for the event is decided through the consultation with the faculty members; the website advertising the event is created and distributed to the general public via email [8]. (2) The funding for the event is solicited from the Faculty of Education, Teacher Education Office, the Department of Curriculum and Pedagogy, and UBC STEM-related institutes and organizations. While the event is run by volunteers, funds are needed for the perishable materials for the activities, food and T-shirts for the volunteers, as well as for other miscellaneous expenses. (3) All teacher-candidates are invited to present a STEM activity of their choice to the general public. Students from other Faculties and campus-wide STEM organizations, such as Let's Talk Science, are also invited. The volunteers are mentored by faculty members from the Faculties of Education and Science. Participating volunteers who are not sure what activity they can offer, are invited to discuss it with the event organizers weeks before the event. (4) On the day of the event, the volunteers come two hours prior to the guests' arrival in order to prepare their stations, set up the registration and signage, and to ensure that the place is ready for more than 350 guests attending the event annually. During this time, teacher-candidates visit the stations supervised by their peers in order to exchange teaching ideas and learn from one another. More than 60 students and faculty volunteers participate in the event every year. All the volunteers are offered breakfast and lunch, and are given an official 'thank you' letter from the Faculty of Education. (5) After the event is over, the feedback is solicited from the attendees and the volunteers via an online survey and informal face-to-face interviews. Finally, event organizers meet to discuss this feedback, reflect on their own experiences, and debate how the event can be improved the following year.

Fig. 1 A teacher-candidate is helping young scientists to explore Bernoulli's principle.

Fig. 3 Discovering the law of reflection via using a plastic transparent screen, a ruler, and two identical candles.

Fig. 2 Exploring non-Newtonian fluids through experimenting with a mixture of cornstarch and water.

Fig. 4 Prof. Valery Milner engages families with the exploration of air pressure.

EXAMPLES OF ACTIVITIES DURING THE FAMILY MATHEMATICS AND SCIENCE DAY

During the day of the event, teacher-candidates facilitate more than 100 different hands-on stations (Fig. 1). A few stations are supervised by teams of secondary and elementary teacher-candidates, allowing them to learn from one another. Some activities, such as exploring non-Newtonian fluids (Fig. 2) or discovering the law of reflection (Fig. 3), require careful guidance, while other activities are more self-explanatory. The activities relate to the entire K-12 STEM curriculum and are set up in multiple classrooms (biology, chemistry and physics teaching labs, two mathematics and two general science classrooms), as well as the hallways of the building. Faculty members from the Faculty of Education, as well as from the Faculty of Science help teacher-candidates to guide many of these activities, thus modeling public outreach to future teachers (Fig. 4). These faculty members also support teacher-candidates in answering visitors' questions and engaging the public in STEM-related conversations.

FEEDBACK FROM TEACHER-CANDIDATES AND GUESTS

Based on the formal and informal feedback from the event collected via an online follow-up survey and open-ended interviews, both elementary and secondary teacher-candidates felt overwhelmingly positive about their participation in the Family Mathematics and Science Day. Many of the future elementary teachers were surprised about their own level of interest in STEM. They also learned a number of practical ideas about engaging their students in STEM learning via using simple experiments with easily available materials. Teacher-candidates communicated STEM ideas to the general public in a positive and productive manner, while also learning about hands-on activities they can implement in their own classrooms. After graduating from the teacher education program, a number of teacher-candidates contacted us to make sure their own students participate in future Family Mathematics and Science Days. We also have a few alumni volunteers at the event annually. The growth of the event

from 95 participants in 2010 to a waiting list of more than 700 enrolling a few days after the event is advertised in 2016 is a testament to its success. Lastly, in response to the requests by future teachers and parents in 2016 we started a YouTube channel for STEM teachers with science and mathematics demonstrations from the Family Mathematics and Science Day that can be performed in K-12 classrooms and at home [9]. The Mathematics & Science Education for All Channel currently hosts more than 50 short videos featuring various STEM experiments from the Family Mathematics and Science Day.

CONCLUSIONS

This report illustrates the importance of engaging future K-12 teachers in STEM outreach. We have had six successful annual Family Mathematics and Science Days so far and we hope that other teacher education programs across Canada will consider engaging future K-12 teachers in STEM outreach. We will be happy to support them via sharing our materials and engagement strategies, should they try to organize a similar outreach event.

ACKNOWLEDGEMENTS

We would like to thank our colleagues and administration from UBC Department of Curriculum and Pedagogy, UBC Pacific Institute for the Mathematical Sciences, and UBC Faculty of Education for their continuing support of the Family Mathematics and Science Day at UBC Faculty of Education.

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IsoSiM Program: Fostering the Next Generation of Science Leaders

by Stuart Shepherd, Lisa Lambert, and Elizabeth Montroy

At TRIUMF, Canada's national particle accelerator laboratory, staff and students know a thing or two about collaborative research. From recreating nuclear reactions at the heart of stars to developing the next best radioisotope for imaging diseases, the laboratory is a hub where multidisciplinary teams come together to tackle a broad range of research problems.

With its activities spanning basic research to commercialization in numerous fields, TRIUMF is involved in a wide diversity of foci which is accompanied by many different requirements for developing and operating specialized infrastructure. In this multidisciplinary environment, TRIUMF community members work together across disciplines, challenging what may be viewed as traditional research silos and formats while fostering a highly collaborative culture. Students in particular experience a highly multidisciplinary milieu and develop instrumental skills in learning to work and thrive collaboratively. They also gain valuable insights into the merits of different outreach approaches. The traditional outreach method typically involves bridging science and society via knowledge sharing with the general public. Another, perhaps less obvious approach (though one that is no less vital to successful interdisciplinary collaboration), is the building of bridges across the various scientific research disciplines by adapting to their different vernaculars and cultures.

"In this era of scientific research, it's not enough for students to endeavour to become experts in just their own field," said Dr. Reiner Kruecken, TRIUMF Deputy Director, Program Director for the Isotopes for Science and Medicine (IsoSiM) program, and UBC Professor of Physics. "It's very important to expose upcoming students to the languages within different research fields."

Summary

IsoSiM is a hands-on, interdisciplinary training program that cultivates capacity for collaboration by providing rich and diverse experiences in the production and application of radioisotopes.

Keywords: Science Technology Engineering and Mathematics (STEM), isotopes, interdisciplinary studies, NSERC CREATE, isotopes, medical isotopes, graduate studies.

This consideration was front and centre when TRIUMF joined forces with the University of British Columbia (UBC) to establish the Isotopes in Science and Medicine (IsoSiM) program. IsoSiM – launched in 2014 with funding from the National Science and Engineering Research Council's Collaborative Research and Training Experience (NSERC CREATE) initiative – provides UBC graduate students with hands-on experience in the production, preparation, and application of isotopes in fields like environmental stewardship, characterization of new materials, investigations of the foundations of the universe, and disease diagnosis and treatment. The IsoSiM program started in April of 2014 and has produced five graduates to date. Currently, there are 26 students in various stages of completing their IsoSiM education and training.

TRIUMF, in alliance with UBC's world-class research programs, leverages its vast isotope expertise to give IsoSiM students an array of experiences as numerous and diverse as isotopes themselves. "At the bleeding edge of science, the boundary between disciplines is inherently blurred," said IsoSiM and UBC Chemistry Ph.D. student Ryan McFadden. "Having expertise in multiple complementary fields is essential for pushing the limits of our understanding." In studying isotopes and the breadth of their applications, trainees gain hands-on experience working with physicists, material scientists, chemists, oceanographers, radiologists, pharmaceutical scientists, and others.

Between the subject matter of isotopes – which have an incredibly wide range of uses – and the multidisciplinary setting of the training program itself, trainees develop outstanding outreach skills that maximize their capacity to collaborate. The IsoSiM management team continually receives feedback from program graduates about the real-life value of the skills they developed in their cohort. "Collaboration between the various disciplines is increasingly important for doing high-quality scientific research," said IsoSiM and UBC Physics Ph.D. student Aris Chatzichristos. "It is important to learn how to communicate effectively with people from different backgrounds, and IsoSiM offers numerous opportunities to do just that."

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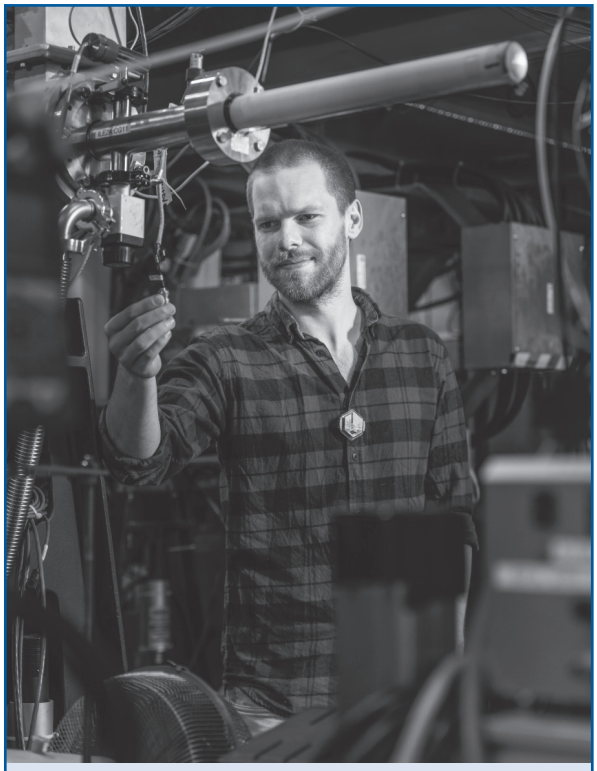

Ryan McFadden, IsoSiM student, Ph.D. student at UBC Department of Chemistry

Zeynab Nosrati, IsoSiM student, M.Sc. student at UBC Faculty of Pharmaceutical Sciences

The IsoSiM program provides a multiplicity of practical experiences, from specialized coursework and international research experiences to summer schools, industrial internships, and public outreach; the diverse curriculum provides trainees with interdisciplinary skills to tackle complex research challenges. Additionally, IsoSiM trainees participate in enriched professional development opportunities, equipping them with high-value vocational skills that amplify their capacity to be team players and quickly make quality contributions to an organization, whether in an academic or industry role. These opportunities include developing their proficiency in advanced research writing, public speaking and engagement, project management, knowledge translation, entrepreneurship, and more. Industry partners themselves also recognize the value in the multifaceted nature of the IsoSiM program. "Companies like mine specifically look for students who are well-rounded," said Dale Tiessen, Regional General Manager of GE Healthcare, an IsoSiM partner. "[IsoSiM]'s intent is to set students up for success no matter where they go."

The IsoSiM program provides trainees with an interdisciplinary repertoire of skills and applied knowledge, and strives to cultivate the next generation of leaders in science and science collaboration. For more information about the program, including application details, please visit isosim.ubc.ca.

TRIUMF is Canada's national particle accelerator laboratory. It is an international centre for discovery and innovation, advancing fundamental, applied, and interdisciplinary research for science, medicine, and business.

GIRLS EXPLORING PHYSICS

BY SARAH D. JOHNSON

As most physicists are aware, women are under-represented at all levels of physics in North America. The situation in Canada is similar to that in the United States where data shows that the fraction of bachelor's degree recipients in physics who are women has remained relatively unchanged since the year 2000 at around 21% [1]. In 2009 a group of women faculty in the Physics Department at Simon Fraser University (SFU) decided to create an outreach program to address this issue. Various studies have shown that the largest decrease in the participation of women in physics occurs between the secondary and post-secondary levels [2] so we decided to aim our program at high school girls, specifically girls in grades 9 and 10. This is the age range when young women in BC are deciding whether to take Grade 11 and 12 physics courses. It is very unlikely that a student will choose to study physics at university if they have not taken physics in high school. Our choice to target only girls is supported by research that has shown that "explicit discussion of under-representation of women in science was positively related to physics identity for female students." [3]

Fig. 1 A participant in the Fall 2014 workshop experimenting with a Van de Graaff generator.

SUMMARY

Girls Exploring Physics is an outreach program at Simon Fraser University designed to encourage more young women to consider physics as a career path.

WORKSHOP DESIGN

Each Girls Exploring Physics (GEP) [4] workshop is comprised of two hour-long experimental physics sessions, a networking lunch with women physicists, an observatory tour and a discussion of career options in physics. Most of the experimental activities closely tie to the research fields of the women faculty in the SFU Physics Department, specifically: soft condensed matter physics, biophysics, solid-state physics, quantum technology and nuclear physics. For example, two of the activities that we have presented are "LED's: Lighting for Efficiency and Drama" where the girls learn how light emitting diodes work and create their own LED device and "Exploring Physics Through Candy" which uses candy as an introduction to soft condensed matter physics. Women faculty and students from the SFU Physics Department as well as women physicists from local industry assist during the activity sessions and attend the networking lunch. The workshops are typically held on a non-school day for the local high schools such as the BC province-wide professional development day in October or during Spring Break. This enables the girls to come to campus individually, though we have noticed that many girls come with their friends or occasionally as part of a school group with a teacher.

Fig. 2 Grade 9 and 10 girls participating in a workshop session on nuclear and particle physics.

HISTORY

The first GEP workshop was held in March 2010 with support from a Jade Bridges Programme grant awarded by the National Sciences and Engineering Research Council Women in Science and Engineering Chair for BC/Yukon. In 2011 GEP received support from WWEST Partners, an initiative of the next National Sciences and

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Engineering Research Council Women in Science and Engineering Chair for BC/Yukon who was appointed in 2010. This funding combined with on-going support from the SFU Department of Physics and Dean of Science enabled us to offer two workshops a year from 2011-2013. In 2015 we were awarded a National Sciences and Engineering Research Council PromoScience grant to improve our program, add new hands-on activities, increase our enrollment and develop a professional development workshop on women in physics for high school science teachers. We also received an additional WWEST Partners grant specifically targeted at the professional development workshop.

From March 2010-2017, GEP has presented 13 workshops, which have reached approximately 600 young women between the ages of 13 and 16. The participants primarily live in the Metro Vancouver regional district though we have had attendees from as far away as the Sunshine Coast, Vancouver Island and 100 Mile House in eastern British Columbia. In addition, our workshop participants, who represent the diversity of the local area, come from many different racial and ethnic groups. Over the last six years more than 100 SFU students, both male and female, seven female physics faculty members, four women who work in local industry and several high school students have volunteered their time to help out with various aspects of the workshops.

EVALUATION

In the past workshop participants were asked to fill out a short evaluation survey. The results of these surveys show that girls consistently find the workshops engaging and they indicate that they have learned new things. For example in the October 2013 workshop survey 40/48 girls rated the activity on LED's as good or very good and 42/48 rated the "Physics of Chocolate" activity as good or very good. In order to follow up with the young women who attended a GEP workshop, a survey of March 2010 workshop participants was conducted in the Spring of 2012. 12/15 (80%) of the survey respondents had taken or were taking Physics 11 and 8/15 (53%) had taken or were taking Physics 12.

Overall these girls show a high interest in pursuing careers in science or engineering with 13/15 (87%) stating that they plan to study STEM subjects at university. We plan to enhance our assessment of GEP in the future by having the girls complete a pre-survey about their educational plans and perceptions of physics before attending the workshop and then do a follow-up survey one or two years later to determine if their survey responses have changed.

FUTURE PLANS

Our next big step is the introduction of a professional development workshop for high school science teachers. This yearly workshop is designed to accomplish three goals: 1) introduce teachers to the issues related to the under-representation of women in physics, 2) provide strategies to address these issues, and 3) give teachers some experience with hands-on physics activities they could incorporate into their own classes. We believe that the GEP program could easily be transferred to another geographic region if the faculty at a university in that region were interested in starting their own program. We would be happy to share details about our hands-on activities and pro-d event with them.

ACKNOWLEDGEMENTS

We would like to thank all of our funding sources including the National Sciences and Engineering Research Council PromoScience grant program, the three most recent National Sciences and Engineering Research Council Women in Science and Engineering Chairs for BC/Yukon, the Department of Physics and the Dean of Science at Simon Fraser University and D-Wave Systems. We would also like to thank the numerous volunteers from SFU and elsewhere and the SFU Faculty of Science faculty and staff, without whose help these workshops would not be possible.

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INQUIRY-BASED EDUCATION AT CANADA'S NATIONAL SYNCHROTRON FACILITY

BY TRACY WALKER, ANNA-MARIA BOECHLER, DAVID MUIR, AND ROBERT BLYTH

SUMMARY

This paper describes inquiry-based education programs at Canada's national synchrotron facility where students learn the process of science in a student-driven environment.

Recent science curriculum reform emphasizes student learning through inquiry practises that mirror the processes and activities of professional scientists [1]. Evidence suggests a decline in innovative student-centred practices as students advance in their education due to heavy content-load, rigidly structured curricula, and a lack of appropriate teacher training [2]. There is also often confusion between the pursuit of inquiry for research purposes (to produce novel information) and for educational goals (provide a learning experience) [3]. Education programming at CLS is based on authentic inquiry experiences that finds a balanced interplay between educational and research goals for high school and undergraduate students. The Canadian Light Source (CLS) is Canada's national synchrotron radiation facility. It has been utilized by several thousand researchers since the beginning of operations in 2005. More than 850 of those researchers are high school students from eight provinces and two territories.

BACKGROUND

There are three cornerstones for all of the education programs at CLS. First, the focus of the experience is on learning *processes* of science, including conventional skills like literature searches, data analysis (Fig. 1) and formulating a hypothesis, as well as teamwork, time management, and communication skills.

Second, the inquiry must be open-ended, meaning that the question or hypothesis must be something for which the answer is not already known. These are experiments, *not* demonstrations. Third, the experience is collaboratively supported by experts but *student* driven. Students work with science mentors, whose role is to provide advice throughout the process, but *decisions* are made by the students. Mentors are drawn from CLS scientific staff and other interested scientists, including graduate students, and the process is facilitated by the Education Team at CLS. Inquiry-based teaching practices are required in most Canadian provincial school curricula and are encouraged at post-secondary institutes. Collaboration between education and research is key.

HIGH SCHOOL PROGRAMS

There are two programs for high school students. Students on the Beamlines (SotB) was initially a single experiment that grew into an award winning program over 10 years [4]. Students from across Canada submit proposals hoping to be granted a single shift of beamtime where they perform an experiment using CLS beamlines, after spending several months working with mentors to develop an appropriate project such as investigating the effects of acid rain on spider silk or tracking chemical changes over time in tree rings. Most groups are extra-curricular clubs comprised of as few as three or as many as 19 students ranging in age from 14 to 18. The projects culminate in student presentations to CLS staff (Fig. 2), to their home communities, a scientific poster and sometimes a paper. This hands-on (Fig. 3) authentic experience has been transformational for the 650 students and teachers [1] that have participated. The result is highly engaged high school students, "We will be allowed to conduct research, not simply have a trial run, but contribute to the scientific community itself, a prospect that is endlessly exciting." [5]

A second school program, still under development, was designed specifically for full classes to participate in an investigation tied directly to learning outcomes in the curriculum, as part of NSERC's Science Odyssey program. In this program, called Light Source Student Experience (LSSE).

Fig. 1 Quebec students cluster to analyse their x-ray spectra data as they prepare to make their first presentation of their findings.

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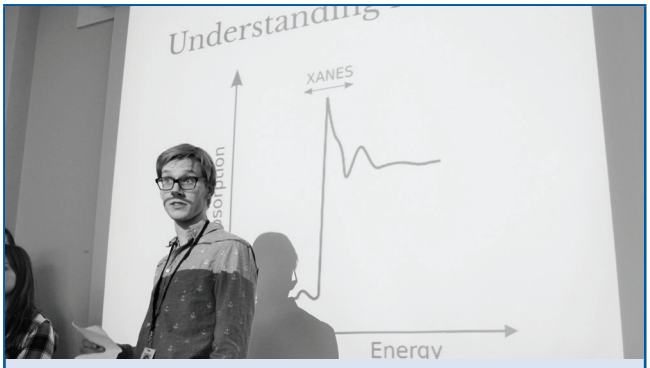

Fig. 2 A Saskatchewan student explains how to read x-ray spectra as part of their presentation to CLS staff.

Fig. 3 A Saskatchewan High School student taking her turn to place a sample in the chamber at the beamline.

Students propose a question relating to soil chemistry and collect samples from their community. Each class returns to their classroom with their data to analyze and with access to data of other classes for comparison. In its inaugural year 199 students participated.

UNDERGRADUATE PROGRAMS

CLS has several pilot projects underway to explore how the three cornerstones of education programming (a focus on process, open-ended inquiry, and collaborative support from experts) fit with undergraduate teaching. At the University of Saskatchewan, on whose campus CLS is located, a group of first-year students taking an Environmental Studies course opted-in for a special project following the SotB model as a replacement for the tutorial section related to the class. This model is also being tested at a distance through a collaboration with, McGill University MacDonald Campus, where their internship program enabled a small group of students to conduct CLS research.

To test a different approach, specialized interdisciplinary courses are offered to third and fourth year students in Chemistry, Education, and Humanities. Students must rely on their own specialized knowledge in the pursuit of a collaborative multidisciplinary experiment, aligned specifically with each department's program as an integral part of the syllabus. These courses are collaboratively taught by department faculty and CLS staff.

TEACHER TRAINING & RESOURCES

In an effort to support teachers who wish to connect current scientific research with curriculum, CLS offers a professional development workshop annually. This workshop also serves as training for the SotB program. Since 2005 more than 180 teachers have attended workshops. If one assumes that each of those teachers taught 75 students each year, that results in nearly 14,000 students connected with scientific research at CLS. In addition, there are a number of teaching resources and lesson ideas available on our website, such as problem-based learning cases involving crystallography and drug design or an information package explaining several different methods of medical imaging and how they are used in diagnostics.

ACKNOWLEDGEMENTS

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PHUNKY PHYSICS AT THE UNIVERSITY OF WINDSOR

BY CHITRA RANGAN

INTRODUCTION

The popular translation of a passage from the Confucian work, the Xunzi, goes, "Tell me and I forget, teach me and I may remember, involve me and I learn." This is the philosophy behind the "Phunky Physics" outreach activities at the University of Windsor. Since 2009, we have sought to give the role of the expert physicist to our undergraduate students by putting them in charge of our outreach activities. The undergraduates are quite independent, and consult the graduate students, and occasionally to faculty members for advice and mentoring. We reach out to the secondary school student population, as well as the public to convey the excitement and joy of Physics.

DEVELOPMENT

In 2010, in celebration of the 50th year of the laser, our students developed two 30-minute programs for physics demonstrations in secondary schools on holography [1], and laser energy transfer [2]. These presentations, and the accompanying presenter manuals, were developed as part of a fourth year course called "Technical Communication Skills" for which I was the instructor. The then Head of the Department, Dr. Bill Baylis, provided a grant of about $200 to develop about 6 demonstrations. The students presented these programs at the "Physics Education Workshop", a day of engagement with high-school physics teachers and students, and drew much appreciation. The same year, as part of the Science Rendezvous [3] public outreach festival (that I organized in Windsor), our students created a large scale non-Newtonian fluid exhibit entitled "Can you walk on water?" This exhibit, that had people incredulously walking across a 6'x4' pool of liquid drew crowds to the University never seen before, and gained a lot of press in the local media. Thus inspired, students have created one major demonstration exhibit annually since then – including the Ruben's tube, fiber-optic communication, the light harp, etc., that have been featured attractions at University Open Houses, and public science festivals such as Science Rendezvous.

SUMMARY

The Phunky Physics Show is a student-run stage-show at the University of Windsor, designed to provide experiential learning and leadership opportunities for our students.

In the spring of 2012, Dr. Steven Rehse built the "fire tornado", a dramatic demonstration of the law of conservation of angular momentum, and added it to our recruitment activities. This engaging demonstration caught the eyes of the producers of the Daily Planet [4], and is now a signature demo at our outreach events as well. At that time, I was serving as Head of the Physics Department, and I challenged the undergraduate students to come up with a stage show on Physics, similar to the Chemistry Magic Shows that were inspired by the Harry Potter™ movie series. The students, researched the experiments, applied to the Department for funding by writing proposals, built the demos, wrote the scripts, and developed the presentations. The faculty provided mentoring when requested, but the students were fairly independent in coming up with this show. The materials needed for this show was mostly taken from old laboratory equipment that was no longer used. Some costs (about $200) was absorbed by the Physics Department. In part due to the publicity gained for the Faculty of Science by being featured in the Daily Planet, we were able to obtain $1000 in funding from the Dean of Science to fund the development of the rest of the demos.

In the fall of 2012, the students premiered the "Phunky Physics Show", an hour-long show using demonstrations involving physics concepts. This show was so successful that the physics undergraduates have been invited to present annually at the Rotary Club Children's Fest. They have also been invited to present the show at local secondary schools as well as at the London Science Museum. The students have managed the transportation of the demos on their own. In the case of a demo that has a health & safety concern, that is not taken off-campus. Each show requires a minimum of four presenters. Students vie for the chance to be a presenter, and they manage a schedule of rotation. Although we did not do a formal assessment of the knowledge gained by the participants, anecdotally, the improvement in confidence of the students as they present topics not covered in class is clear.

Figure 1 shows some of the experiments that the students have developed, and the evolution of activities from an exhibit format to a show format. Interestingly, students have adopted the lab coat as a signature when they do these shows, a garb that the faculty's generation does not associate with Physics. Most students participate

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Fig. 1 The outreach activities developed by our students have evolved from an exhibit format to a popular stage show called the "Phunky Physics Show". Clockwise from top-left: Ruben's tube (a visual demonstration of sound waves), magnetic levitation (demonstration of the Meissner effect in superconductors as the temperature falls below the Curie temperature), fire tornado (conservation of angular momentum), gyroscope (gyroscopic precession), plasma ball (generation of electromagnetic energy, and production of plasmas), fiber-optic communication, speed of sound (to show that sound does not travel in a vacuum), water pipe (total internal reflection) (centre).

enthusiastically in these activities for fun. Students who take on leadership roles in a particular year receive an entry in their co-curricular transcript. The current Head of Department, Dr. Steven Rehse, continues to be supportive of the Phunky Physics Show. Faculty and graduate students will often suggest demo ideas to the undergraduates, who have the final decision in what gets developed. The Phunky Physics Show is now one of the key activities of the Physics Club, which is a student organization composed of undergraduate Physics majors.

CONCLUSION

Participation in physics outreach activities has provided students a variety of experiential learning opportunities at the University of Windsor. Students demonstrate the ability to communicate with an expert viewpoint to the general public. Students have used the co-curricular transcript to demonstrate their outreach & leadership capabilities in their career development. The Physics Department also benefits from the strong sense of community built by these shared experiences.

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Bringing Quantum to the Masses

by Martin Laforest and the Communication and Strategic Initiatives Team

We are at the cusp of a technological revolution – the quantum information revolution. Technologies harnessing the counter-intuitive behaviour of atoms and molecules, such as the powerful quantum computer, unbreakable quantum cryptography and quantum sensors for medical, geological and chemical applications, are poised to get out of the labs, and into people's lives. The majority of the population does not realize that the first quantum revolution gave us devices including computers, cell phones, LED lights, MRIs and grocery store scanners [1]. The second quantum revolution, based on quantum information technologies, will have an even deeper societal and economic impact. This quantum future will require a STEM workforce and general population that are quantum-aware [2].

Fig. 1 Exploring wave-particle duality using light polarization.

This report discusses some of the specific scientific outreach efforts the Institute for Quantum Computing (IQC) at the University of Waterloo has developed to target high school teachers and students and the general public.

SCHRÖDINGER'S CLASS: TEACHING THE TEACHERS

The basic concepts of quantum mechanics are part of many high school physics curricula in Canada [3,4], but the allocated time to teach them is very limited. Anecdotal evidence suggests that a large portion of high school teachers lack the confidence in teaching the material. Quantum mechanics is a complex subject and a deep understanding is necessary in order to teach it effectively [5]. "By exposing teachers to more methods and more content, we give them the confidence to expand their classroom practice to reflect current understandings and current content." [6]

Schrödinger's Class (Fig. 1) is a three-day workshop for high school physics teachers designed to deepen the educators' understanding of quantum mechanics and give them hands-on resources to bring into their classroom. Some activities offer a new twist on curriculum material, while others discuss applications of quantum mechanics and quantum information and they could serve as extra-curricular activities in class or for science clubs. These include the use of quantum superposition to achieve unbreakable information security, or the use of quantum interference to perform a quantum computation.

The first two editions of Schrödinger's Class have attracted 50 participants and have been praised with an overall experience of 3.9/4.0 on average. Some educators left satisfied with their new level of understanding and others have already used some of the activities as part of their teaching material. The activities presented during Schrödinger's Class are currently being formatted into teacher resources and will be available online in

Summary

The Institute for Quantum Computing develops workshops for students and teachers and a travelling museum exhibition to raise awareness about quantum mechanics and quantum technologies.

Key words: Science Technology Engineering and Mathematics (STEM), scientific outreach, quantum mechanics, student enrichment programs, teacher training, public programming.

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the near future. Schrödinger's Class is offered on the first weekend on December and will expand in size in the coming years.

QUANTUM CRYPTOGRAPHY SCHOOL FOR YOUNG STUDENTS

Since 2008, IQC has been offering the Quantum Cryptography School for Young Students (QCSYS), a grades 11-12 enrichment summer program for talented and curious students wishing to learn more about the beauty and importance of quantum mechanics. QCSYS has become a highly competitive and prestigious eight-day program that welcomes 45 exceptional students from all over the world every summer.

Fig. 2 Visitors experiencing a full classical and quantum simulation of the double-slit experiment.

Quantum cryptography is the most market-ready quantum information technology and we use it as the narrative to teach mathematics, quantum mechanics and their technological applications. The program is a blend of traditional lectures, hands-on experiments, peer-instruction and group work. Students explore various concepts of quantum mechanics, both through a phenomenological approach and then quantitatively using basic linear algebra and complex numbers. The students are then exposed to the classical and quantum cryptography and learn how quantum optics turns these ideas into real hardware devices. By the end, they have the opportunity to design and build their own version of a quantum cryptography system.

Parallel to the academic program, the school includes various social activities in the evenings, a trip to Niagara Falls and two mentoring sessions where students have the opportunity to meet and discuss with IQC's researchers. Past students have left very satisfied with their experience, giving QCSYS an average rating of 4.8/5.

In addition to QCSYS, IQC continuously develops quantum-related activities. By visiting and hosting high school groups and partnering with other outreach organizations, IQC delivers face-to-face programing to upward of 1200 students annually.

QUANTUM: THE EXHIBITION – CELEBRATING CANADIAN QUANTUM INNOVATION

Through IQC's public talks and annual open houses, thousands of science enthusiasts from the Waterloo Region have been exposed to quantum information science and technology and the ways it will shape the technological landscape of tomorrow. Acknowledging that Canada as a nation plays a leading role in this technological revolution, we wanted to bring awareness about the second quantum revolution to as many Canadians as possible. A travelling museum exhibition was deemed the perfect vehicle for that.

QUANTUM: The Exhibition is the first-ever travelling exhibition about quantum information science and technology. It stands at 4000 square feet and is designed to engage a variety of audiences. By using a well-balanced mixture of written content, interactive activities and multimedia displays, neophytes are exposed to the wonder of the quantum world, while people with previous knowledge still learn something. There are also enough levers to pull, buttons to push and screens to touch to engage young children.

To expose the audience to the beauty and power of quantum mechanics and quantum technology, the exhibition is broken into three sections. The first section is all about quantum mechanics, where the visitor is exposed to the fundamental concepts, like wave-particle duality, quantum superposition, interference, and uncertainty (Fig. 2). The second, smaller, section is about information technology, a necessary detour needed to fully appreciate the third section about quantum information technology. In this final section, the visitor learns and experiences quantum computing, quantum cryptography and quantum sensors.

The exhibition opened in Kitchener in October 2016 and travelled across Canada in 2017, with stops in Vancouver, Saskatoon, Calgary, Halifax and Ottawa. QUANTUM: The Exhibition has already reached upward of 150 000 Canadians and has been widely praised for its simplicity, originality and design. Starting 2018, the exhibition will travel the world.

CONCLUSIONS

The overarching goal of IQC's outreach efforts is to raise awareness about the beauty, but also the importance, of quantum mechanics and how it will play a significant role in tomorrow's technological landscape.

ACKNOWLEDGEMENTS

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PICTURE THIS: USING PHOTO-RESEARCH EXHIBITS AS SCIENCE OUTREACH†

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INTRODUCTION

Gender imbalance in science, technology, engineering, and math (STEM) is not only a concern from a social justice perspective, but also has negative consequences for scientific innovation [1] and the economy, given that lack of workplace gender diversity is associated with lower revenue and returns [2]. It is therefore imperative for research scientists in academia and industry to identify ways to attract and retain women in STEM to ensure diversity and equity, economic viability and success in scientific endeavors. Science outreach (i.e., public outreach by scientists) could be particularly impactful in Waterloo, Ontario – a region known as 'Canada's Silicon Valley' that contributes over $30-billion annually to the global economy [3]. However, Kitchener-Cambridge-Waterloo was recently named one of Canada's worst regions to be a woman, linking gender disparities in the technology sector to the countries' largest gender-wage gap [4]. Thus, science outreach should be especially valuable in Waterloo, given the region's opposing reputations as a STEM powerhouse and an unfavorable place for women.

Situated at Wilfrid Laurier University in Waterloo, Ontario, the Laurier Center for Women in Science (WinS; www.wlu.ca/wins) aims to attract women into STEM fields, celebrate women's scientific contributions, and to address challenges faced by women in science. As a group that welcomes all genders, WinS supports the full participation of all people in science to improve gender equity, strengthening Canada's scientific innovation, and diversifying leadership across academia, government and industry. WinS hosts various outreach initiatives; for example, a guest speaker series featuring women in STEM fields. To encourage engagement, WinS also explores new approaches to science outreach that may be more relevant to current students, many of whom are immersed in image-based social media platforms like Instagram [5]. Here, we discuss one such innovative outreach initiative – interactive research-based photo exhibits on sexism in science.

SUMMARY

Is a picture worth a thousand words? This paper discusses a unique science outreach initiative – provocative photo-research exhibits on sexism in science.

PHOTO-RESEARCH EXHIBITS

Communicating effectively with images is challenging; for example, the complexities of the concept can be lost if the image is too simple. Alternately, the simplicity of an image can sometimes be more powerful than thousands of words. Portraying complex social issues using a visual medium has the potential to be accessible to a diverse audience. Images from two photo-research exhibits *#DistractinglySexist* (2015) and *#DistractinglyHonest* (2016) were based on social-psychological literature and findings from research by two of the authors (Hennessey and Foster) on the social costs of confronting sexism in science [6]. After initial concept development, collaboration with photographer Hilary Gauld and graphic artist Sarah Mueller allowed us to transform the concepts into reality.

#DistractinglySexist: Confronting Sexism in Canada's Tech Triangle

The *#DistractinglySexist* exhibit consists of eight portraits of female scientists ranging from a fourth-grade aspiring neuroscientist to full professors at Wilfrid Laurier University. The title of the exhibit was chosen to be a deliberatively provocative spin on a recent comment by a Nobel Prize Laureate who referred to women in the lab as 'distractingly sexy' (https://goo.gl/KvNm2Q). Through use of text, the exhibit narrative states that there is a persistent gender imbalance in science (and especially so in Physics versus other disciplines). If women choose to confront this imbalance, they may incur serious social costs (i.e., retaliation), which might discourage speaking out. If women were equipped with tools (e.g., exposure to mentors [7], a strong science identity) to buffer the costs of confronting sexism, they may be more likely to remain in science, which could reduce gender inequities and ultimately, positively impact social change. This narrative is interspersed with the exhibit

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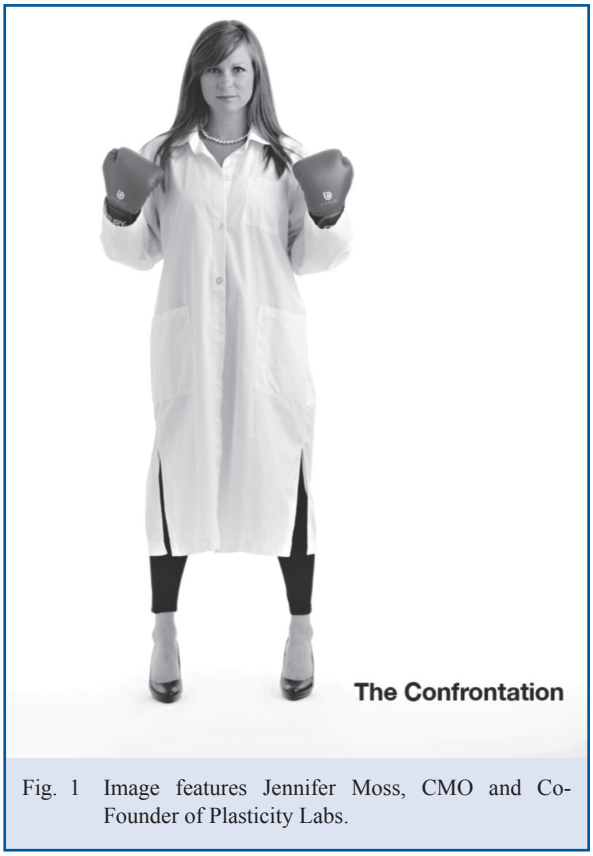

Fig. 1 Image features Jennifer Moss, CMO and Co-Founder of Plasticity Labs.

images to inspire thought and provide context. The exhibit drew a broad range of audiences, received national media coverage (e.g., CBC; https://goo.gl/CGyNdE), and toured institutions in Canada and the US, including Harvey Mudd College and the California Institute of Technology.

Each piece is paired with social-psychological literature and research findings [6]. For instance, the image in Figure 1 would be accompanied by this text:

> In non-STEM contexts, women incur social costs when they confront sexism; confronters fear retaliation and are viewed negatively by others as 'complainers' [8], [9]. According to the Role Incongruity Model of prejudice, hostile prejudice is elicited when people enact stereotype-incongruent social roles [10]. Considering STEM careers are stereotypically masculine [11], the mere presence of women in science roles versus more feminine roles will likely elicit heightened hostility. Further, confrontation, an active versus passive behaviour, is also inconsistent with female stereotypes (i.e., submissiveness [12]. Women in stereotype-incongruent STEM roles who also confront may therefore incur a 'double dose' of hostility as they violate gender stereotypes in two ways.

#DistractinglyHonest: Confronting Sexism in STEM

A follow-up photo-research exhibit presents challenges faced by women in STEM from different perspectives. *#DistractinglyHonest* consists of 13 portraits of female scientists and their allies, and one collage piece portraying a periodic table featuring women scientists. This second series addresses issues like the role of childhood socialization, work/life balance, and gender identity. Individual pieces can be displayed using chemistry stands and clamps, creating an immersive science outreach experience. The follow-up series is more extensive than its predecessor, reflecting the widespread interest garnered by the original installation. Featured scientists were from Wilfrid Laurier University, York University, Ryerson University, the Lassonde School of Engineering, and community organizations.

The *#DistractinglyHonest* narrative demonstrates the complexities around issues related to women in science; for instance, the text accompanying one piece states: "Advances in gender equity in STEM have occurred in the last few decades, leading some people to believe that men and women are *#HonestlyEqual*." The next piece responds to this idea by stating a different perspective: "Honestly speaking, men's and women's experiences often differ drastically in STEM - women indicate harassment, social isolation, stereotyping, and a struggle to maintain work/life balance, which is *#HonestlyChallenging."*

Assessing Reactions: Outreach or Outrage?

Recently we started survey research to examine the potential effects of these exhibits among participants and patrons. The exhibits utilize quick response (QR) codes linked to an online survey: (https://goo.gl/wvUJkM) and include questions such as, "Have you learned anything new about gender disparities in STEM since engaging with the exhibit materials?" "To what extent do you think the exhibit will impact people's understanding of gender disparities in STEM?" and "To what extent did you enjoy engaging with the exhibit?" where scores ranged from 1 (*Not at all*) to 5 (*A Great Deal*). While data collection is ongoing, preliminary analyses show that on average, those who have engaged with the exhibits find the experience educational, impactful, and enjoyable. Specifically, descriptive statistics showed that average scores on the previously cited questions were all > 3.70, well above the scale mid-point. The survey also includes various open-ended questions (e.g., "How do you think the exhibit will impact people's understanding of gender imbalances in STEM?"). When asked to describe the impact of the exhibit, one featured scientist said:

> It was empowering to be involved with this exhibit. I tell women in STEM to build their networks - find their supportive communities - and being involved in this exhibit made me feel more connected to my network of like-minded, supportive, women (and allies) in STEM. It was also a fun and very different kind of experience for me, as a long-time scientist - who rarely gets the opportunity to be involved in different approaches to telling our stories.

Some survey respondents explicitly recognized the exhibits as a call to action. For instance, one person commented, "It's a great visual wake-up call, done respectfully, but not quietly either." Another way the exhibits function as outreach tools

is by facilitating group discussion. Recently a group of physics educators (OAPT) viewed *#DistractinglySexist* and then responded to four discussion questions (e.g., "What are the challenges female students and minorities face in a physics classroom?"). Responses indicated that educators perceived various challenges that impact underrepresented students, including stereotyping, low confidence, lack of role models, and underrepresentation in instructional materials. In this instance, the exhibits facilitated discussions on gender disparities in STEM among those teaching physics, a discipline in which women remain severely underrepresented (20% of physics graduates in Canada are female [13]).

CONCLUSION

Patrons and participants of the photo-research exhibits described in this paper report positive experiences. Feedback on the exhibits as science outreach tools indicate one notable strength of the exhibits is that they create a space for diverse groups, including all genders, to discuss sexism in science. Moreover, the exhibits are situated within empirical research, increasing the validity of the installations. Taken together, feedback indicates that *#DistractinglySexist* and *#DistractinglyHonest* are effective outreach tools. Specifically, they appear to facilitate discussions on sexism in science, and expand the social network of women in science by connecting those in the series and people who engage with exhibit materials. To date, the exhibits have travelled both locally and internationally, reflecting their widespread positive reception among STEM and non-STEM audiences alike.

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Outreach Opportunities for Undergraduate Students through the Physics Communication Course at the University of Guelph

by Joanne M. O'Meara, Christian Schultz-Nielsen, and Martin Williams

During our curriculum mapping exercise in 2013/2014, we closely examined the role that each course played in the development of the desired graduate attributes of our students. As a result, our program has undergone an extensive update, with 5 courses deleted, 6 new courses added, and 9 existing courses significantly restructured. This restructuring afforded us the opportunity for a more intentional approach to developing communication skills, which is identified as one of the five core components of undergraduate and graduate education at the University of Guelph.

More specifically, the five key learning outcomes identified by the University of Guelph are:

- Critical and creative thinking
- Literacy
- Global understanding
- Communicating
- Professional and ethical behaviour

The university goes on to specify that communicating is "the ability to interact effectively with a variety of individuals and groups, and convey information successfully in a variety of formats including oral and written communication. Communicating also comprises attentiveness and listening, as well as reading comprehension. It includes the ability to communicate and synthesize information, arguments, and analyses accurately and reliably." [1] In addition, communication and interpersonal skills are identified as two of the criteria by which the CAP's Professional Certification Committee assesses physics-related work experience in the professional designation process [2].

Summary

In 2014, we launched our updated undergraduate program. Students are now required to take our Physics Communication course, sharing their passion for physics with different audiences.

Our redesigned program now requires all of our majors to take a course in third year that focuses on communicating physics to diverse audiences. As a result, there is a natural partnering of the curricular intentions of this course with our departmental commitment to public outreach. The following outlines our plans for honing our students' abilities to interact effectively with a variety of individuals and groups, and convey information successfully in a variety of formats through the first offering of this new course in the winter semester of 2017. In the revised program, our second, third, and fourth year physics laboratory courses have also been redesigned to strengthen the technical writing and presenting skills developed during the undergraduate experience at the University of Guelph, in keeping with the recommendations of the AAPT Laboratory Curriculum document [3].

COMMUNICATIONS COURSE STRUCTURE

Students are required to complete three major summative assessments during the semester, along with smaller formative assessments throughout. The major components include an individual writing project, an oral presentation, and a group project. The smaller formative assessments will explore important elements of writing and oral communication as we build towards these more significant course assignments. In addition, there are weekly readings, videos to watch, or podcasts to listen to before class. Students earn participation marks by coming to class prepared to critique these selected pieces in our group discussions.

Writing Project

Graded by the instructor, the format of the writing project is selected by each student from a list of possible options, such as a newspaper article or a story for a popular science publication (such as *Scientific American*) on a recent development in physics, a briefing document for a politician as background material for a request for significant government funding, a manuscript for a children's science/physics book, or a guest commentary for the opinions/analysis section of a major publication that addresses a controversial physics subject in the public domain.

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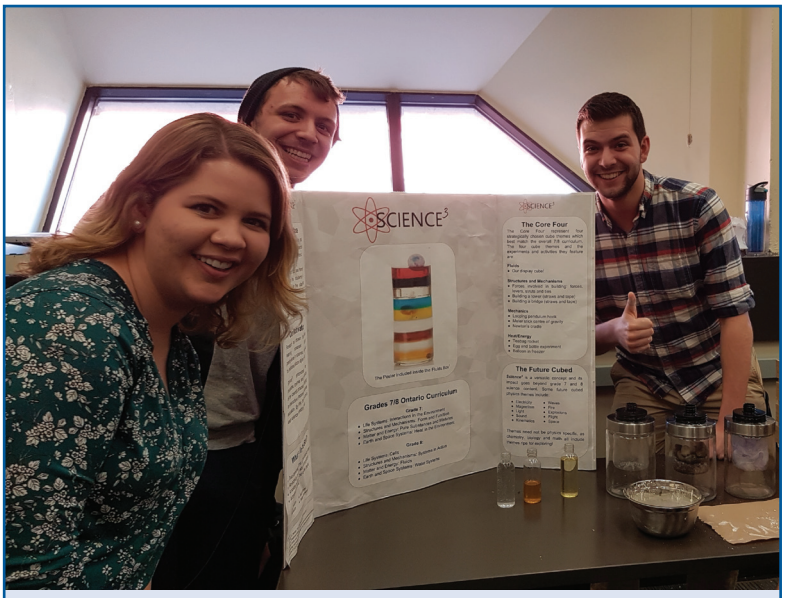
Working towards this significant assignment, all students in the course participate in formative writing exercises that focus on matching structure, content, and style to the target audience.

Oral Presentation

Graded by peer assessment and the instructor, students will choose their own physics topic to present to the class. In the initial offering of this course, the scenario for this presentation is a classroom visit at the elementary or secondary school level, to discuss a specific topic from the mandated physical sciences curriculum. Each year the target audience for this final presentation will change. Working towards this final presentation, students will participate in formative exercises that explore the key elements of orally communicating information and analyses in a clear, accurate, and engaging manner.



Physics students (left to right) Danielle St Jean, Dan Cureatz, and Eric Boucher stand with their display at the Open House presentations of the final group projects in PHYS*4300.

Group Project

Assessed by the community through an end-of-semester open house, as well as by the instructor, the capstone group project will draw upon skills developed in writing, oral presentations, as well as some aspects of multimedia design depending on the format chosen by each group. Potential formats from which the students can choose include: designing and creating a short physics-related YouTube video, developing a hands-on, low cost, activity kit for a particular physical science topic in the K-12 curriculum [4], or writing and creating a physics-themed podcast. These projects also provide opportunities to develop collaborative working skills. The group projects are the clearest example of the synergy between the goals of the communication course and those of our departmental outreach initiatives. Visitors to the open house are provided with a structured rubric for assessing the group projects on display, which is also provided to the students in the course as they work on these projects. Faculty, staff, students, as well as local high school physics teachers are invited to attend. Involving the wider community in the open house will be explored in future offerings.

CONCLUSIONS

We are excited about our plans for enhancing the communication skills of our students, while simultaneously expanding our outreach initiatives. As with all curricular developments, there will be an evolution as we learn what works and what doesn't in the context of this course in the coming years. Regardless of the specifics of the course structure in the future, however, we are committed to providing our students with opportunities to learn effective ways to share their passion and enthusiasm for physics with diverse audiences.

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MEDICAL PHYSICS OUTREACH AT RYERSON UNIVERSITY

BY GRAHAM PEARSON

Medical physics is a relatively young but fast-growing sub-field of physics applied in modern healthcare, most notably in cancer diagnosis and treatment. Founded in 2006, Ryerson University's Department of Physics recognized an opportunity to provide specialized programs focused on this important field. Today Ryerson provides a Bachelor of Science degree program in Medical Physics, as well as Master of Science and PhD degree programs in Biomedical Physics.

Not long ago astrophysicist and popular educator Neil deGrasse Tyson made an astute observation that "if you take a tour through a hospital and look at every machine with an on and off switch that is brought into the service of diagnosing the human condition, that machine is based on principles of physics discovered by a physicist, in a machine designed by an engineer" [1]. There are indeed ample examples of physics practiced in healthcare, from the introduction of the stethoscope 200 years ago [2], to the diagnostic applications of X-rays, ultrasound, and MRI, to therapeutic nuclear medicine. In tandem, healthcare's dependence on medical physics creates diverse employment opportunities. Medical Physicists' roles range from running oncology clinics, to critical support provided by radiation therapists and technologists. At the same time research, development, and manufacturing of medical devices continue to grow and employ many more medical physics experts.

Tyson makes the case that society needs to prioritize ongoing investment in sciences in order to continue to advance healthcare, and that we need to foster greater public awareness of the role of basic science, such as physics, in healthcare to build more support for this important goal. However, while the significance of medical physics in healthcare is clear, it does remain relatively unknown to the general public, making it difficult to attract talented students into the field.

SUMMARY

Ryerson University's Department of Physics offers a Medical Physics degree program. An outreach program has been developed to build greater awareness of the field among regional secondary school students.

Consequently, promoting Ryerson's Medical Physics program offers challenges and opportunities that we've aimed to address in part by developing an immersive outreach program that gives the Greater Toronto Area high school students a taste of university physics with emphasis on medical applications.

BACKGROUND: BUILDING AN OUTREACH PROGRAM

In 2012, Ryerson's Faculty of Science established the Office of Science Outreach and Enrichment (OSOE)†, whose mission is to make science engaging, comprehensible, and accessible to the general public, and to better coordinate promotional activities previously fragmented across individual University departments. Regional high schools – there are over 140 in the Toronto area – are invited to visit and participate in campus tours led by undergraduate students. Following the tour students visit a teaching laboratory to participate in a 2-hour hands-on lab-based activity in a particular subject of interest. There are presently offerings in Chemistry, Biology, Computer Science, Mathematics, and Physics.

THE PHYSICS WORKSHOP: ELECTRONICS FOR SCIENCE, LIGHT, NOISE, AND ART

The reality of recruiting to a Physics or Medical Physics program from a class of high school physics students seems to be that fewer than 1 in 20 students is seriously considering pursuing physics at a post-secondary level‡. Our Electronics for Science, Light, Noise, and Art workshop was developed with this in mind, placing heavy emphasis on keeping the activities informative but entertaining. The "light, noise, and art" components help engage even those participants who have no ambitions to pursue physics at all beyond the secondary level. By keeping technical activities entertaining, we aim to convey that even an informal interest in physics and electronics increases technical literacy and can be very worthwhile and creative.

† OSOE program information is available at www.ryerson.ca/scixchange.
‡ Based on informal polling of student participants.

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The two-hour workshop allows 15 or 20 minutes to welcome students and provide orientation describing the first year university science experience. It also allows enough time to introduce the field of medical physics, and to point out the unique aspects of Ryerson's Medical Physics program. We touch briefly on the specializations of the Department's faculty members, like high intensity focused ultrasound (HIFU), a non-invasive method of tumour tissue ablation, or photoacoustic microscopy, where cell health can be characterized based on the thermal-acoustic shockwave signature generated from a laser pulse. We also highlight opportunities for students to collaborate with our faculty and adjunct faculty from local hospitals, particularly during their fourth year thesis course studies.

After the introduction we jump straight to circuits and have the students work in pairs to build a very simple current-limited LED circuit. The students are provided a small kit[§] containing an electronics prototyping board, resistors, capacitors, jumper wires, plus an LED and 9V battery. Web-based "connect-the-dots" style instructions guide the students in assembling the LED, resistor, and battery components into specific holes on the prototyping board to create a simple circuit loop. When powered on inevitably only half the circuits operate correctly until the LED orientation is corrected to allow forward-biased diode conduction, which initiates a quick discussion about semiconductors, current, Ohm's law, and conservation of energy.

The second circuit has the students assemble an amplifier-based "relaxation oscillator," which raises the excitement level when their LED begins to blink. The students are asked to swap certain components and to note the effect on the blink rate. The LED is soon swapped for a piezoelectric speaker to generate entertaining buzzing noises. During a quick recap we reflect on how changing certain components dramatically alters the circuit's frequency, reintroducing ideas like ultrasound touched on in the introduction, and making connection to electromagnetic radio waves and their role in common technology like radios and telecommunications.

By this point their comfort level with the kits is usually increasing so the third activity foregoes "connect-the-dots" instructions in favour of a schematic diagram as the students independently assemble a "light theremin." In this circuit a photodetector actively modulates an oscillator's frequency, creating a rough-sounding but very entertaining musical instrument as students experiment by waving their hands rhythmically over the detector to cause squealing noises. The recap for this activity makes the connection that we have moved from "static" to "dynamic" circuits, with active sensing components that could be used for practical scientific measurements or engineering. With each activity the students have acquired increasingly complex skills and tools.

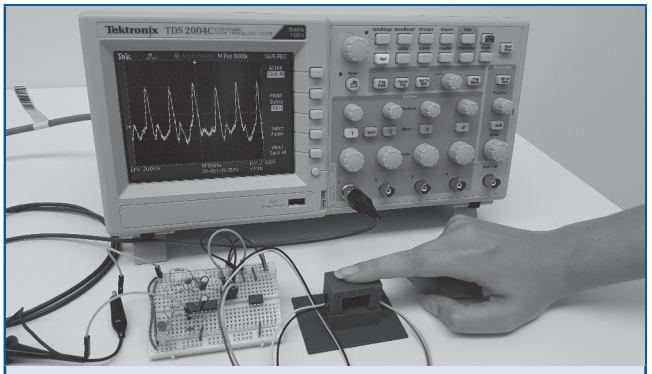

Fig. 1 Heartbeat sensor in operation.

For the final half hour of the workshop, students are given a schematic for a slightly more complex "mystery circuit," and begin a friendly competition to see which group can successfully complete the assembly first. When connected to an oscilloscope the circuit's secret is revealed as the students realize that the rhythm they observe on the scope is their own heartbeat (Fig. 1). The circuit acts as an optical pulse sensor, non-invasively tracking heart rate as each pulse of blood to the capillary vessels of the finger modulates the amount of infrared light reflected to a small phototransistor.

Overall, based on teacher evaluation and student feedback, the workshop is consistently well received. We hope the experience serves to entice more science-oriented students to seriously consider careers in STEM and, particularly, medical physics-related fields. To go from little or no experience in building electronics to assembling a functioning heart monitor in only a few hours gives a great sense of accomplishment. Most importantly, the workshop clearly conveys to all the outreach program participants the significant role physics plays in modern healthcare.

To view the web-based support pages for the electronics activities offered, see www.physics.ryerson.ca/electronics-workshop.

§ Additional kit components include LM324 op-amp, 555 timer, CdS photoresistor, piezoelectric crystal, and matched IR LED and phototransistor. One-time cost of kit components is about $10.

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For more information on arranging visits, see www.ryerson.ca/scixchange.

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Science Rendezvous: Innovation in Science Outreach for Canada

by Kelsey A. Miller

Science Rendezvous (SR) is Canada's largest STEM (science, technology, engineering, and math) festival, annually reaching over 300,000 Canadians across nearly every province and territory [1]. SR is a collaborative outreach model that has grown from 4 university partners in 2008, to 300 simultaneous events in partnership with 135 research institutes, universities and community groups, supported by 6,000 volunteers in 2016. By providing a framework for collaboration that effectively pools the resources of all parties, SR is able to produce an outreach event of greater size and scope than any one organization can accomplish independently.

Activities vary between event sites depending on the specializations of the hosting institution. However, the core program components remain consistent: Science Carnival, INVENTours, Science Chase, Canada-Wide Experiment, and Northern and Aboriginal Science Program. The "Science Carnival" is an outdoor festival that includes large-scale installations and departmental pavilions where scientists display their research through hands-on activities and interactive exhibits (Fig. 1). This part of the SR festival offers direct involvement with world-class science, and the actual scientists doing it, making the event a unique experience for participants of all ages.

Fig. 1 Learning together under the big tent of the Science Rendezvous festival.

"INVENTours" opens the doors to over $5B of premier laboratories providing unprecedented public access to the specialized facilities that are driving scientific discovery in Canada. INVENTours places participants directly in the research setting. Scientists offer tours of their labs and research facilities detailing the research conducted, and the tools used to take ideas to discovery. This behind the scenes look into a career in science is a crucial first step in enabling a child to imagine themselves in that role, and begin thinking of themselves as future scientists [2-4]. "The most important aspect of the event is that it breaks down the

Summary

Science Rendezvous brings the public face-to-face with scientists through innovative outreach strategies that provide interactive experiences of the research taking place in Canada.

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barriers to science and shows the community that the field doesn't have to be intimidating, and helps them believe that a career in science is possible for them", says Julia Piché, scientist volunteer at SR University of Winnipeg.

The "Science Chase" is based on the television series The Amazing Race, and is designed to engage a sports-focused audience. Science Chase is a competition that motivates and directs participants to engage with scientific concepts through a series of problem solving "challenges". These challenges teach about different areas of science (the body, solar system, chemistry, physics, etc.) in an obstacle course format. Participant survey results show over 50% of 2015 Science Chase attendees had not previously attended any science outreach activity, indicating the importance of this kind of innovative strategy to increase new audience engagement with STEM.

In 2017 the Canada-Wide Experiment will take the form of self-contained experimental kits that allow youth and teachers to study water quality across Canada. The Canada-Wide Experiment actively engages participants in all aspects of the scientific process. Environmental sensors included will measure water temperature, pH, VOCs (volatile organic chemicals), and heavy metals. The kits will travel across the country as a mobile laboratory, allowing participants to track and compare results. This program brings the entire country together in a unified project, establishing an inclusive scientific community across vast distance.

The Northern & Aboriginal Science Program operates in close partnership with local elders and community leaders, creating a knowledge exchange wherein scientists travel to remote access and Aboriginal communities to work with elders and teachers in developing locally relevant experiments that will inspire curiosity in STEM fields. These "Travelling Scientists" bring with them resources and materials to coordinate a local SR event as part of the national initiative, and facilitate participation in the Canada-Wide Experiment, thereby bringing the SR festival experience to communities that would otherwise not be able to participate. This kind of direct engagement with scientists is the most important aspect to effective science outreach, and the core component of all SR activities.

In addition to tracking the number of event attendees, SR has disseminated a participant Impact Survey since 2014 [4]. This survey is used to determine specific event engagement and impact. In 2016, 85% of respondents found SR "Quite Educational" or "Very Educational", 89% of participants found it "Quite Enjoyable" or "Very Enjoyable" (for reference, choices included "Not at all", "Slightly", "Somewhat", "Quite" and "Very"). Attendees were also questioned on how the event compared to their local Science Centre, with more than 92% stating that it was "as good" or "better", indicating the power of a free science festival to successfully attract and engage participants. As one enthusiastic respondent noted, "Your event did more than my efforts or years of "Mad Science" classes or Science Centre membership did…The demos were great, but even better were the volunteers who shared their passion in such an effective way with my daughter (and me)." Further results of the survey included that 62% were first time attendees and 87% of attendees intend to return next year, both of which indicate potential for future growth.

SR acts as a lightning rod of excitement that works alongside our partner organizations' outreach activities, such as visiting scientist programs and clubs that sustain the scientific curiosity reinvigorated by SR. A broad range of outreach strategies, and collaboration among practitioners is crucial to establishing new audiences and inspiring the next generation of researchers and innovators [5]. The importance of the SR outreach model to the perception of science in Canada is now being recognized by the Natural Sciences and Engineering Research Council of Canada (NSERC), which has designated SR as the marquee event of its 10-day campaign known as Science Odyssey [6].

New and innovative methods of science outreach are necessary to access the best and brightest in Canada. This is what SR offers, constant reimagining of science outreach strategies, based on real science and current research taking place in Canada. There is no substitute for the impact real scientists can make as role models to the next generation. There is no one else who can communicate the genuine excitement of scientific enquiry than those actively involved on a daily basis. SR provides an important platform for public engagement with these thought leaders on a vast scale.

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HIGH SCHOOL OUTREACH BY POSTSECONDARY STUDENTS

BY MIRIAM HEWLETT AND SVETLANA BARKANOVA

SUMMARY

We describe our approach to high school outreach. Our aim was to improve the effectiveness of this outreach towards female high school students.

Why is the force of gravity so weak? Why are there three generations of matter particles? Why are their masses so different? These are some of the most interesting questions in particle physics, which, among many other areas like fusion power, nanotechnology, etc., are some of the most prominent in physics today. However, most material included in high school physics courses is pre-20th century classical mechanics, meaning many students are not exposed to these exciting ideas. Hence, reaching out to secondary schools with information about such areas is especially important. Bluteau and Barkanova [1] mention three major arguments in support of having this outreach performed by postsecondary physics students. Firstly, lessening the age gap between the students and the presenter may remove barriers caused by seniority and increase the quality of communication, as postsecondary students would have more recently gone through high school themselves. Secondly, another advantage to involving students as presenters is the valuable experience it gives to them, allowing for the development of important communication skills. Thirdly, having postsecondary students organize and perform science outreach eases the burden on professors who often have limited time due to their involvement in research as well as teaching.

Building upon this successful outreach program [1], presentations were organized again with a female undergraduate student. Female enrolment in physics in Canada is less than in many other areas in STEM, with only 22% of undergraduate physics degrees being earned by women in 2012 [2]. Research supports the importance of having female role models in motivating women to pursue STEM fields [3,4]. Thus, it was thought that having a female student performing the outreach could improve its effectiveness towards female students in particular. Like the reduced age gap, having a female presenter may remove barriers felt by female students.

METHOD

In the Spring of 2016, Acadia University honours student, Miriam Hewlett, who had previously started exploring subatomic physics research opportunities with Dr. Svetlana Barkanova, was funded by Women in Science and Engineering (WISE) Atlantic to visit nine high schools in Nova Scotia and provide over 350 students with an introduction to the field of subatomic physics. First, to help in introducing Hewlett to the teachers, we had an article published on Acadia's website [5] about her research and other interests, like volunteering for Acadia's Sensory Motor Instructional Leadership Experience (S.M.I.L.E.) [6]. Initially 45 teachers were contacted with an offer to come to their classes; however, we found that these "cold emails" often went unanswered, as only three replied, including Hewlett's previous high school teacher in Cape Breton. Following this result we turned to Dr. Lynn Aylward of Acadia University School of Education, with whom we had consulted about the presentation's structure, for help. Through Aylward's connections, Hewlett was able to get in contact with another of the local high schools and set up some more presentations. Following these visits, teachers were asked if they knew of anyone who might like to have a guest presenter. After hearing that they'd been mentioned by other teachers who had welcomed visits, teachers were much more likely to respond; in fact, all of the teachers contacted this way arranged for presentations to be given.

The majority of the presentations were given in grade 11 and 12 physics classes, but a less in-depth presentation was given to some students taking general science or math courses. The presentations consisted of a 45-minute lecture, with the majority of the time spent giving an introduction to the Standard Model. After covering this necessary background, some of the current research going on in particle physics was discussed, in particular the discovery of neutrino oscillations. A Nobel Prize in Physics in 2015 had been awarded to Dr. Arthur B. McDonald, originally from Sydney, NS, providing an excellent local role model for the students. Along with having a woman give the

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Fig. 1 A sample of the material included in Hewlett's presentation. Following an introduction to the Standard Model and research in particle physics, Hewlett shared her undergraduate experience and discussed some of the misconceptions students may have about pursuing a physics degree.

presentations, care was taken to include photos of successful female physicists. Students are more likely to pursue fields in which they believe they have a chance to succeed [7], so seeing the success of other women in physics is very important for female students. Lastly, Hewlett's undergraduate physics experience, the future honours thesis she would be completing under the supervision of Barkanova, and possible careers in physics were also discussed. As mentioned by Aylward, "the idea that you have to be a 'science person' or an 'arts person' has to go" [8], so we emphasized that an interest in music or sports does not preclude one from becoming a physicist. Following the presentations there was also a question period where students had a chance to inquire about the material. This gave the students an opportunity to clear up some uncertainties they might have had about pursuing physics in university and as a career, and to hear this from a postsecondary student going through the process herself.

RESPONSE

The outreach was very well received by both teachers and students. The students were engaged and responded to the chance to ask about physics related questions unrelated to their class material, like the subject of gravitational waves, neutrinos, etc. Many students were also interested in taking physics in university and looked for advice. For example, some were interested about the advantages and disadvantages of going to a small university like Acadia, and others worried that majoring in physics would require sacrificing time for other things like sports, volunteering, social activities, etc. Having an undergraduate student make a presentation and talk about their research opportunities and involvement in extracurricular activities allowed for the chance to discuss these uncertainties in a very relatable context. The students were also very interested in what kind of careers would be available to them with a degree in physics; female students especially were curious about Hewlett's plans after her undergraduate degree.

Following the presentations, teachers mentioned that it was beneficial to have students relate the subject that they were learning about in class to an exciting field like particle physics. Many of the grade 12 physics classes were just beginning their modern physics units, so the timing of the presentations worked well. It was also noted by one of the teachers that it was interesting to learn about some of the prominent roles currently filled by women in physics, specifically, in this case, about the current Director-General of CERN, Dr. Fabiola Gianotti.

CONCLUSION

There are many exciting fields in physics, as well as other sciences, that are often not touched on in high school. Outreach like this, done by an undergraduate student, is a great way to show high school students a glimpse of the possibilities available to them. Having a postsecondary student give these presentations has many advantages, especially in that it allows students to hear from a relatable source about studying physics in university. Furthermore, in hopes of improving its efficacy towards female students, this outreach was done by a female presenter and prominent female physicists were explicitly mentioned. We hope that this article may prompt a discussion about the employment of postsecondary students, especially female students, in outreach.

ACKNOWLEDGEMENTS

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REPORT ON THE 6TH INTERNATIONAL IUPAP CONFERENCE FOR WOMEN IN PHYSICS

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The 6th conference in the series of *International Union of Pure and Applied Physics (IUPAP) International Conferences on Women in Physics* was hosted by the University of Birmingham from July 16 to 20, 2017. It was organized by the Working Group on Women in Physics (WGWIP) of IUPAP, the Institute of Physics in the UK (IOP), the University of Warwick and the University of Nottingham. Over 300 delegates from 48 countries attended the meeting, including a diverse Canadian team with seven members that included faculty members, graduate and undergraduate students, and a member of WGWIP (Dr. Shohini Ghose).

The program of the conference fostered multidisciplinary, cross-cultural discussions, interesting and inspiring presentations on the career paths and research interests of eminent female physicists. Programming included poster presentations on the status of women in physics across various countries, physics research posters, challenging and stimulating workshops, and unique networking opportunities. Topics of discussion included the underrepresentation of women in physics, breaking gender stereotypes, conscious and unconscious bias towards women physicists, pay inequality compared to male physicists, and attrition of women as they continue to climb the academic ladder [1].

One of the conference highlights was the presentation of the Institute of Physics (IOP) President's Medal to Professor Dame Jocelyn Bell Burnell "for her outstanding contributions to physics through pioneering research in astronomy, most notably the discovery of the first pulsars while a Ph.D. student in Cambridge, and through her unparalleled record of leadership within the community" [2]. The award praises the Fellow of the Royal Academy and Dame Commander of the Order of the British Empire as "a champion in encouraging women to study the physical sciences, noting her contribution to establishing the Athena SWAN awards for commitment to advancing the careers of women in science" [2].

Following the award presentation, Professor Bell Burnell shared with the audience her perspectives on challenges she faced during the past 50 years as a woman researcher in astrophysics who persevered in her struggle to achieve a balance between her family duties and an outstanding career in physics, "a male dominated field". Professor Bell Burnell told the audience: "We've assumed the problem is with the women, not with the way scientific society works. Be persistent. Take risks – surprise yourself! One failure does not make a disaster. Aim as high as you can. Keep your options open. Make women braver, more willing to put in grant applications, to apply for promotion, to apply for jobs. Get a prize for the institution that's the most women friendly... and they'll compete for it!". She ended her thought-provoking talk with a quote by Laurel Thatcher Ulrich: "Well-behaved women seldom make history". Regarding institutional changes, Professor Bell Burnell remarked that "several UK funding agencies require a university / department to have the Athena Swan accreditation before applying for grants."

The plenary speaker, Professor Dame Athene Donald spoke of many 'firsts' including being the "first woman to be professor in a UK university and Master of a Cambridge college" [3], often the only woman on scientific or policy-making committees, a trailblazer for women in physics and a "gender champion at Cambridge" [3]. She referred to herself as "a woman showing that science is a normal activity for women to do". Her contributions to the physics community are outlined by Dr. Jessica Wade in her blog [3]: "She began initiatives to support women returning from maternity leave, offered CV advice and frameworks for promotion, ran workshops on confidence and impostor syndrome [4] , and helped postgrads with career advice. But with great power came great responsibility – from broadcast to print media, everyone wants Donald's comment. Today, she advises broadly, from academia to pre-19 education and even parliament and the hardest part is learning to say "no" to other people's requests". The advice Professor Donald offered during her talk, entitled "Reflections on Not Fitting In", included the following: "The need for support does not go away, although the form in which is required may change"; "Friends, mentors and sponsors are all-important"; "If you hit roadblocks, you can either let them block you, knock them down, or find ways around them"'; and "I believe scientists should use every opportunity to talk about science on mainstream radio as opposed to (but not instead of) specifically science programs".

During the conference dinner the delegates were addressed by the President-Elect of IOP, Dame Julia Higgins, one of the founders of the UK Athena Swan (Scientific Women's Academic Network) charter in 1999 in the UK. She was "the first woman to become both a Fellow of the Royal Society and of the Royal Academy of Engineering" explains Jessica Wade [3]. Discussing the low numbers of women in physics a few decades ago, Dame Julia Higgins said: "I had always assumed that if I looked over my shoulder there would be more following up behind, but there weren't". She added, "The best thing that I could do for women in science was to be one and to be successful."

The workshops were filled with interesting discussions, hands-on exercises and demonstrations on the following topics: Gender Studies and Intersectionality; Improving the Workplace/ Science Practice and Ethics; Professional Development and Leadership; Cultural Perception and Bias; and Physics/Science Education. As part of the Gender Studies and Intersectionality workshop series, Canadian team member and social psychology Ph.D. Candidate Eden Hennessey presented an overview of gender studies and provided an introduction to the concept of intersectionality. "Across the workshop sessions, some attendees expressed concern about addressing too many identities instead of examining only gender, which is, in itself, still a prevalent issue. These conversations suggest that discussing research on intersectionality is still needed to fully communicate how different identities interact to create unique and challenging circumstances for women in physics" said Hennessey.

The last plenary talk of the conference was delivered by the former spokesperson for the Laser Interferometer Gravitational-Wave Observatory (LIGO) project, Professor Gabriela Gonzales of Louisiana State University. In order to succeed, the LIGO project pushed the sensitivity, noise level, and amount of light captured by the observatory beyond the state-of-the-art so that they could study very distant astrophysical phenomena. Speaking of the first detection of gravitational waves on September 15th, 2015 Professor Gonzales told the audience: "It has been very exciting, but it's going to be even more exciting." "Lots of people think success is a big discovery" but "success is being happy in what you do".

The social program included a classical music concert by a 15 year-old very talented musician, Lauren Zhang. Lauren is already a winner of several prestigious national and international prizes for her piano performances. Other conference highlights included the unveiling of the digital exhibition by local artist, Dr. Annie Mahtani, in collaboration with the Chair of the ICWIP conference's Local Organizing committee, Professor Nicola Wilkins, and anthropologist Liz Hingley. The exhibition, entitled "Finding Space - Celebrating what it is to be 'a woman in Physics' '", presented inside the world's tallest free standing clock tower, was based on pictures of themselves and their work environment submitted by over 200 conference delegates.

The conference ended with a surprise visit from the youngest ever Nobel Peace Prize laureate Malala Yousafzai. In her address to the ICWIP delegates, a thoughtful and humble Malala spoke of the importance of education for young girls and the need to get young girls interested in science at a young age through joint efforts of "schools, parents and communities" [3]. She told the audience, "I decided to speak out because there was no other option. If you stay silent nothing will change". She also presented an overview of her recent "Girl Power Trip" with the Malala Fund [5].

In sum, the facts and statistics presented by delegates, and the discussions that occurred at the conference, clearly demonstrated that the worldwide status of women in physics has improved since the inception of this conference series in 2002. To ensure that the observed trend for recruitment, retention and career progress continues to improve in all countries represented at the conference, the delegates approved several resolutions that will be presented to the IUPAP General Assembly by representatives of the IUPAP Working Group on Women in Physics.

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REPORT OF OUTGOING PRESIDENT

RAPPORT DU PRÉSIDENT SORTANT

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My year serving as president of the Canadian Association of Physicists came to an end at the 2017 Congress at Queen's University. It is my distinct pleasure to present to you my reflections looking back upon that year, occasionally going back a little further, and also to give you my thoughts on the future of the Association.

To put it mildly, the year ending June 2017 was an eventful one for the Association – and indeed for the world at large. The CAP saw a number of substantial changes over the year, with more on the horizon.

DECONSTRUCTING THE CAP

If you are reading this, chances are you are a member of the CAP (if not, please go immediately to www.cap.ca and click on the green button labelled "JOIN THE CAP"!) Therefore, you have a pretty good idea of what the CAP is. Myself, I have been a member since the 1990s, and soon got involved in the running of the Association (as a regional councilor and on the executive of the Division of Theoretical Physics, and somewhat peripherally as a member of the editorial boards of *Physics in Canada* and of the *Canadian Journal of Physics*). Given this experience, when Gabor Kunstatter (past president at the time) called me up in February 2014 and asked me if I would consider joining the Executive of the Association, I was confident that I was intimately familiar with the CAP and its activities.

I was wrong.

As I progressed from Vice-President Elect to Vice-President to President and now to Past President, with each year I have learned more and more about the breadth of the CAP's activities and how much goes on behind the scenes. I also had the pleasure of working with a devoted, hard-working staff and an amazing and dedicated group of volunteers both on the Board of Directors and the Advisory Council – but more on that later.

Given my own superficial understanding of the organization at a time when I felt I knew it well, it is perhaps worth running through the various components of the CAP (as represented by its Board of Directors) which will help you understand many of the behind-the-scenes (as well as some not-so-behind-the-scenes) activities of the CAP. Hopefully it will even inspire

Mon année à la présidence de l'Association canadienne des physiciens et physiciennes a pris fin au Congrès 2017 à l'Université Queen's. J'ai le vif plaisir de vous présenter mes réflexions sur cette année-là, remontant parfois un peu plus loin, et de vous livrer aussi mes pensées au sujet de l'avenir de l'Association.

C'est peu dire que l'année terminée en juin 2017 a été riche en événements pour l'Association – et même pour le monde entier. L'ACP a assisté à divers changements importants au cours de l'année et d'autres pointent encore.

DÉCONSTRUCTION DE L'ACP

Puisque vous lisez ceci, il y a des chances que vous soyez membre de l'ACP (sinon, veuillez aller immédiatement à https://www.cap.ca/fr/ et cliquer sur le bouton vert « DEVENEZ MEMBRE »)! Vous avez donc une très bonne idée de ce qu'est l'ACP. J'y ai moi-même adhéré dans les années 90 et j'ai tôt fait de m'occuper de la marche de l'Association (à titre de conseiller régional et de membre de la direction de la Division de la physique théorique et, un peu indirectement, des comités de rédaction de *La physique au Canada* et de la Revue canadienne de physique). Fort de cette expérience, lorsque Gabor Kunstatter (ancien président à l'époque) m'a appelé en février 2014 pour me demander si je songerais à devenir membre de l'Exécutif de l'Association, j'étais convaincu de très bien connaître l'ACP et ses activités.

Je me trompais.

En gravissant les échelons de vice-président élu à vice-président, puis à président et maintenant à président sortant, chaque année m'a fait connaître de plus en plus l'ampleur des activités de l'ACP et la somme énorme de travail qui se fait dans l'ombre. J'ai aussi eu le plaisir de travailler avec un personnel dévoué et assidu et un groupe extraordinaire et dévoué de bénévoles, tant au conseil d'administration qu'au conseil consultatif – mais je reviendrai là-dessus.

Vu ma propre compréhension superficielle de l'organisation à un moment où je croyais bien la connaître, il vaut peut-être la peine de revoir les divers éléments de l'ACP (représentés par son conseil d'administration), ce qui vous aidera à bien comprendre ses activités en coulisses (et les autres moins en coulisses). Cela inspirera même certains d'entre vous à s'engager,

some of you to get involved; help is always appreciated! So, in alphabetical order, the portfolios of the Board of Directors are:

Academic Affairs. Unless you are a Physics Department chair, you are probably unaware that the CAP concerns itself with academic affairs. Currently overseen by the Director of Academic Affairs, Donna Strickland (University of Waterloo), the main focus is fostering a strong relationship with the physics departments across Canada to ensure that we serve their needs as best we can. The relationship is indeed very strong and fruitful (although – subtle hint to department heads and chairs – a better response rate to the annual survey of departments would help us serve you better!). This Director also represents the CAP on the CAP-NSERC Liaison Committee, a very important interface between the physics community and its primary funding agency.

Communications. I recall meeting the Director of Communications, Marcello Pavan (TRIUMF), at a Council meeting a few years back. Marcello expressed the opinion that the CAP is a communications organization with a physics perspective. I thought he was nuts at the time, but I have grown to fully embrace his view. Communications pervades virtually every activity of the Association, and I will be discussing our recent communications efforts and developments at length below.

Industrial Affairs. The CAP would not be the voice of all Canadian physicists if it were made up entirely of academics. We realize we must work hard to make ourselves more relevant to physicists in industry. That is the mandate of the Director of Industrial Affairs, Ian D'Souza (Honeywell Aerospace), who has, among other initiatives, worked on sessions getting students together with perspective employers at various CAP- sponsored events (most notably our Congress), which not only serves his constituency of industrial physicists but also the CAP's student affiliates.

International Affairs. Physics, like any field of research, knows no borders, and a strong relationship with our sister societies throughout the world is not only good for Canada but good for physics. Jens Dilling (TRIUMF) was Director of International Affairs during my year as president, and that position is now filled by Ritu Kanungo (St. Mary's University/TRIUMF). This Director chairs the Canadian National IUPAP Committee and carries responsibility for developing the slate of nominations for the IUPAP Commissions every three years.

Members and Affiliates. The CAP has a number of different membership/affiliateship categories (individual physicists and physics teachers at all levels, departments, corporations, institutions); Director Steven Rehse (University of Windsor) has, with great passion, taken charge of our efforts to increase membership in all categories. Again, I will go into this in more detail below.

espère-t-on; une aide est toujours appréciée! Voici donc, par ordre alphabétique, les portefeuilles du conseil d'administration

Affaires académiques. À moins que vous ne soyez directeur d'un département de physique, vous ignorez probablement que l'ACP s'occupe d'affaires académiques. Actuellement sous la gouverne de la directrice des Affaires académiques, Donna Strickland (Université de Waterloo), l'accent est surtout mis sur l'établissement de liens étroits avec les départements de physique de tout le Canada pour assurer que nous répondions au mieux à leurs besoins. Ces liens sont effectivement très étroits et fructueux (bien que – subtile allusion aux directeurs de départements – un meilleur taux de réponse au sondage annuel des départements nous aiderait à mieux vous servir!). La directrice représente aussi l'ACP auprès du Comité de liaison ACP- CRSNG, lien très important entre la collectivité de la physique et son principal organisme de financement.

Communications. Je me rappelle ma rencontre avec le directeur des communications, Marcello Pavan (TRIUMF), à une réunion du conseil il y a quelques années. Marcello s'était dit d'avis que l'ACP était un organisme de communication sous l'optique de la physique. À l'époque, je l'avais cru cinglé, mais j'en suis venu à partager pleinement son point de vue. Les communications envahissent presque toutes les activités de l'Association et j'exposerai plus loin nos réalisations et efforts récents en ce domaine.

Affaires industrielles. L'ACP ne serait pas le porte-parole de tous les physiciens du Canada si elle ne rassemblait que des universitaires. Nous constatons que nous devons travailler dur pour devenir plus pertinents aux physiciens dans l'industrie. Voilà le mandat du directeur des Affaires industrielles, Ian D'Souza (Honeywell Aerospace) qui, entre autres initiatives, a concocté des sessions visant à réunir des étudiants et d'éventuels employeurs lors de divers événements parrainés par l'ACP (notamment à notre congrès), ce qui ne sert pas uniquement son groupe de physiciens de l'industrie mais aussi les étudiants affiliés de l'ACP.

Affaires internationales. Comme tout autre domaine de recherche, la physique n'a pas de limites et ses liens étroits avec nos sociétés sœurs du monde entier sont bons non seulement pour le Canada, mais également pour la physique. Jens Dilling (TRIUMF) était directeur des Affaires internationales pendant mon année à la présidence et ce poste est maintenant occupé par Ritu Kanungo (Université St. Mary's/TRIUMF). Cette directrice préside le Comité national canadien de l'UIPPA et a charge d'établir la liste des candidats aux commissions de l'UIPPA tous les trois ans.

Membres et affiliés. L'ACP a diverses catégories différentes de membres/affiliés (physiciens seuls et professeurs de physique à tous les niveaux, départements, sociétés, établissements); le directeur Steven Rehse (Université de Windsor) a assumé avec grande passion nos efforts en vue d'accroître les adhésions dans toutes les catégories. À nouveau, je reviendrai là-dessus plus en détail.

Professional Affairs. One major priority for the CAP is to increase the stature of the profession of physicist. This complex, multi-faceted problem calls for a multi-faceted approach. One effort in this direction falling within the mandate of the Director of Professional Affairs (Mike O'Neill [Ontario Hydro, ret'd] during my year as president; currently Daniel Cluff [CanMind Associates]) is to enhance the profession through measures such as the introduction of the P.Phys. certification. This program is overseen by the Professional Certification Committee chaired by Mick Lord (Investors Group). The goal is to get employers to appreciate the fact that physics graduates will excel in just about any field where analytical skills and problem-solving are important assets, so that rather than employers placing ads seeking people with a degree in engineering or a related field (such as physics), they will seek people with a degree in physics or a related field (such as engineering).

Science Policy. Advocacy on behalf of physics and physicists is obviously an immensely important priority for the CAP. This is the purview of the Science Policy Committee, headed by Director Kris Poduska (Memorial University of Newfoundland). Once again, more will be said below about some of the CAP's science policy efforts during my presidency.

Student Affairs. The Director of Student Affairs, Corina Andreoiu (Simon Fraser University), oversees the Student Affairs Committee, whose goal is to develop initiatives involving students (including the various student conferences) to improve student engagement with the CAP. Improved student engagement will hopefully lead to more students staying with the CAP as they progress from studying physics to putting it to good use either in academia, industry or government.

The remaining Board members are the signing authorities for the organization and form the Board Executive. In addition to the Executive Director (salaried staff position responsible for the operations of the CAP office), the Secretary-Treasurer (responsible for overseeing the finances of the Association and the CAP Foundation), there are four positions on the Presidential line. Once a volunteer is elected to the Board in the position of Vice-President Elect, they will transition into each successive role annually, carrying responsibility for different CAP programs/activities, as follows: **Vice-President Elect** – Lecture Tour, Best Student Paper Competition; **Vice-President** – Annual Congress; **President** – represents the CAP at various meetings and events (e.g. makes a presentation about the CAP at the Fall meeting of the APS); and Past-President – securing nominations for the open positions on the Board and Advisory Council.

DEVELOPMENTS: 2016-2017

Over my year as president, the CAP has of course maintained its traditional suite of activities, including but not limited to:

Affaires professionnelles. Une grande priorité de l'ACP est d'accroître la stature de la profession de physicien. Cette question complexe aux facettes multiples nécessite une approche multiforme. Un effort en ce sens entre dans le mandat du directeur des Affaires professionnelles (Mike O'Neill [Ontario Hydro, à la retraite] pendant mon année à la présidence; actuellement, Daniel Cluff [CanMind Associates]) compte améliorer la profession par des mesures telle l'instauration de l'accréditation Phys. Le Comité d'accréditation professionnelle, présidé par Mick Lord (Investors Group), s'occupe de ce programme. L'idée est d'amener les employeurs à apprécier le fait que les diplômés en physique excelleront dans presque tous les domaines où les compétences en analyse et en solution de problèmes sont des atouts importants, de sorte qu'au lieu de placer des annonces pour trouver des diplômés en génie ou dans un domaine connexe (comme la physique), les employeurs chercheront des diplômés en physique ou dans un domaine connexe (comme le génie).

Politique scientifique. Le plaidoyer en faveur de la physique et des physiciens est une priorité fort importante pour l'ACP, de toute évidence. C'est l'apanage du Comité de la politique scientifique, que dirige Kris Poduska (Memorial Université de Newfoundland). Encore une fois, je reviendrai plus loin sur certains efforts déployés par l'ACP en matière de politique scientifique au cours de ma présidence.

Affaires étudiantes. La directrice des Affaires étudiantes, Corina Andreoiu (Université Simon Fraser), voit à la marche du Comité des affaires étudiantes qui a pour objectif d'élaborer les initiatives à participation étudiante (dont les diverses conférences pour étudiants) afin d'améliorer leur engagement envers l'ACP. Un meilleur engagement amènera un plus grand nombre d'étudiants à demeurer à l'ACP, espère-t-on, dans leur marche entre les études en physique à l'utilisation de leur savoir dans les universités, l'industrie ou auprès de l'État.

Les autres membres du conseil d'administration sont les signataires de l'organisation et forment la direction de ce conseil. Outre le directeur exécutif (poste salarié qui a charge du fonctionnement du bureau de l'ACP), le secrétaire-trésorier (chargé de superviser les finances de l'Association et de la Fondation de l'ACP), la ligne présidentielle compte quatre postes. Une fois qu'un volontaire occupe le poste de vice-président élu du conseil d'administration, les titulaires assument successivement chacun de ces rôles tous les ans, prenant charge des différents programmes/activités de l'ACP, comme il suit : **vice-président élu** – Tournée de conférenciers, concours du meilleur exposé étudiant; **vice-président** – au Congrès annuel; **président** – représente l'ACP à divers événements et réunions (p. ex. fait un exposé sur l'ACP à la réunion de l'automne de l'APS); et président sortant – veille à avoir des candidats aux postes ouverts du conseil d'administration et du conseil consultatif.

FAITS NOUVEAUX : 2016-2017

Au cours de mon année à la présidence, l'ACP a maintenu sa série habituelle d'activités, bien sûr, y compris mais non de façon limitative :

- Congress 2017; preparing for Congress 2018 (yes, preparing for the Congress is a long-term undertaking!)
- Medals and awards; prize exams
- CAP Lecture Tour
- Student conferences (Canadian Undergraduate Physics Conference (CUPC), Canada-America-Mexico (CAM) Graduate Student Physics Conference, Canadian Conference for Undergraduate Women in Physics (CCUWiP))
- *Physics in Canada*
- Divisional activities
- Engaging with MPs, with funding organizations, and with other advocacy groups

In addition, there have been several major initiatives taken to work towards the four goals espoused in our 2014-2018 Strategic Plan (available on the CAP web site), which are:

- To Strengthen the Profession of Physics
- To Improve the Visibility of Physics and Physicists in Canada through Excellence in Communications
- To Effectively Advocate at All Levels the Value of Physics and Physicists
- To Achieve Organizational and Operational Excellence to Provide Services in an Effective, Efficient and Transparent Manner

These initiatives include:

Communications. I sincerely hope you have all noticed the new CAP web page, which is a great improvement both visually and functionally over the old web page. We have also reorganized our communications such that most information transmitted to members comes in one of two forms: news bulletins and news flashes. All the above, as well as a new letterhead, logo, powerpoint template, banners, increased social media presence, youtube channel, etc., are as set out in branding documentation established over the last year or two through the CAP's efforts to improve communications, most notably through the hiring of communications consultant Gina Grosenick, who has been immensely helpful in developing and implementing our communications strategic plan.

Physics in Canada. Also in the general area of communications, Physics in Canada now has a fully searchable archive of all its content since its first issue in 1955. After several years' work, the launch occurred on 25 January, 2017. The ease with which the full content of the site can be retrieved reinforces the role of *Physics in Canada* in archiving the history of the CAP and its community. The accessibility and permanence that this system offers greatly enhances the value for authors to publish in *Physics in Canada*, value that will be enhanced further once the archives are formatted to be collectible by Google Scholar (stay tuned!). If you have not already done so, I recommend browsing the archive (available

- le Congrès 2017; préparer le Congrès 2018 (oui, préparer le Congrès est une entreprise à long terme!)
- les médailles et prix; les examens primés
- la Tournée de conférenciers de l'ACP
- les conférences étudiantes (Conférence canadienne des étudiants en physique (CUPC), Conférence d'étudiants diplômés de physique Canada-États-Unis-Mexique (CAM), Conférence canadienne des étudiantes au 1er cycle en physique (CCUWiP))
- *La physique au Canada*
- les activités des divisions
- l'engagement auprès des députés, des organismes de financement et d'autres groupes de défense d'intérêts.

En outre, il y a eu plusieurs grandes initiatives visant à atteindre les quatre objectifs de notre Plan stratégique 2014-2018 (disponible sur le site Web de l'ACP), qui sont:

- renforcer la profession de physicien
- accroître la visibilité de la physique et des physiciens au Canada par l'excellence des communications
- faire valoir efficacement à tous les niveaux la valeur de la physique et des physiciens
- atteindre l'excellence sur le plan de l'organisation et du fonctionnement afin de prodiguer des services de façon efficace, efficiente et transparente.

Ces initiatives englobent les points suivants :

Communications. J'espère sincèrement que vous avez tous vu la nouvelle page Web de l'ACP, beaucoup plus attrayante et conviviale que l'ancienne. Nous avons aussi réorganisé nos communications de sorte que la majeure partie de l'information transmise aux membres prend deux formes : bulletins et messages. Tout ce qui précède, ainsi qu'un nouvel en-tête de lettres, logo, modèle powerpoint, bannières, présence accrue sur les médias sociaux, chaîne YouTube, etc., sont des points réglés dans les documents d'image de marque établis ces deux dernières années par les efforts de l'ACP pour améliorer les communications, notamment par l'embauche de la consultante en communications Gina Grosenick, qui a été immensément utile dans l'élaboration et la mise en œuvre de notre plan stratégique en matière de communications.

La physique au Canada. De plus, dans le domaine général des communications, *La physique au Canada* a maintenant des archives dont le contenu est pleinement interrogeable depuis son premier numéro paru en 1955. Après plusieurs années de travail, le lancement a eu lieu le 25 janvier 2017. La facilité à retrouver le contenu entier du site renforce le rôle de *La physique au Canada* par ses archives sur l'histoire de l'ACP et de sa collectivité. L'accessibilité et la permanence offertes par ce système offrent une valeur nettement améliorée pour les auteurs qui publient dans *La physique au Canada*, valeur qui sera encore plus grande une fois que les archives seront formatées de manière à pouvoir être recouvrées par Google Scholar (suivez cela de près!). Si vous ne l'avez pas déjà fait, je vous

through the Publications link of the CAP web page, www.cap.ca, or directly at https://pic-pac.cap.ca) to explore recent and not-so-recent developments in Canadian physics.

Science policy. It was a big year for science policy in Canada, with the change in government in late 2015 slowly leading to some very interesting developments in Canada. One exciting development was the announcement of a Fundamental Science Review. The CAP, through its Science Policy Committee, made a submission to the Panel, one of whose members was Art McDonald of Queen's University (longtime CAP member and 2015 co-recipient of the Nobel Prize in Physics).

The Committee's Report (the Naylor Report), which came out in April 2017, gave a sober, somber assessment of science funding in Canada, making a large number of recommendations for changes in the oversight of funding of research in Canada as well as recommending substantial increases in funding in order for Canada to maintain and enhance its standing in fundamental research internationally. An overview of the report, and the CAP's reaction to it (overall very positive!), were presented in a Science Policy/CAP-NSERC Liaison Committee Joint Workshop at the 2017 Congress. The workshop panel included Art McDonald as well as APS President Laura Greene of Florida State University.

Equality, Diversity, and Inclusion (EDI). Many of you will remember a Committee for the Encouragement of Women in Physics (CEWIP) panel discussion on diversity at the 2017 Congress. The discussion, which featured Art McDonald and Laura Greene (a hearty thanks to both of them for taking such an active role at the Congress!) as well as Elizabeth Boston (NSERC), A.W. Peet (University of Toronto, current CEWIP chair) and Shohini Ghose (Wilfrid Laurier University, current CAP VP Elect), was the CAP's first effort (to my knowledge) to broaden its efforts in diversity beyond women in physics. This was a first step in this direction, and I fully expect that in a year's time Stephen Pistorius, in his Outgoing President's Report, will be describing further activities and initiatives advancing equality, diversity and inclusion.

On a related note, I am proud that the 2016 Congress at the University of Ottawa which began my presidency had the first-ever female Herzberg speaker (Victoria Kaspi of McGill University) – a first that was long overdue, it must be said – and that the Herzberg speaker at the upcoming 2018 Congress at Dalhousie University which will end my year as past president will be the second female Herzberg speaker (Nergis Mavalvala of MIT). Given that the Herzberg Memorial Lecture is the main Congress event open to the public, representation by women and other underrepresented groups is very important; may the trend continue!

recommande de naviguer dans les archives (accessibles par le lien « Publications » de la page Web de l'ACP (à https://www.cap.ca/fr/, oudirectement à https://pic-pac.cap.ca) pour explorer les faits nouveaux récents et pas si récents de la physique au Canada.

Politique scientifique. Ce fut une grosse année pour la politique scientifique au Canada, par suite du changement de gouvernement fin 2015, qui nous a apporté petit à petit des faits nouveaux fort intéressants au Canada. L'un deux, passionnant celui-là, est l'annonce de l'Examen des sciences fondamentales. L'ACP, par son Comité de la politique scientifique, a présenté un mémoire au groupe d'experts dont faisait partie Art McDonald de l'Université Queen's (depuis longtemps membre de l'ACP et colauréat du Prix Nobel de physique 2015).

Le rapport du Comité (rapport Naylor), paru en avril 2017, est une évaluation sobre et sombre du financement des sciences au Canada et recommande un grand nombre de changements à la surveillance du financement de la recherche au Canada de même que d'importantes hausses du financement afin que le Canada puisse maintenir et améliorer sa place en recherche fondamentale sur l'échiquier international. Une vue d'ensemble du rapport et la réaction de l'ACP à celui-ci (très positive dans l'ensemble!) ont été présentées à un atelier conjoint du Comité de liaison de l'ACP-CRSNG sur la Politique scientifique au Congrès 2017. Les experts de l'atelier étaient Art McDonald et la présidente de l'APS, Laura Greene, de Florida State University.

Égalité, diversité et inclusion (EDI). Nombre d'entre vous se souviennent du débat d'experts du Comité visant à encourager les femmes en physique (CEFEP) sur la diversité au Congrès 2017. Ce débat, auquel participaient Art McDonald et Laura Greene (un grand merci à tous deux pour avoir joué un tel rôle actif au Congrès!), ainsi que Elizabeth Boston (CRSNG), A.W. Peet (Université de Toronto, actuel président du CEFEP) et Shohini Ghose (Université Wilfrid-Laurier, actuelle v.-p. de l'ACP), est la première (que je sache) tentative de l'ACP pour accroître ses efforts de diversité au-delà des femmes en physique. Ce fut un premier pas en ce sens et je m'attends bien, dans un an, à voir Stephen Pistorius décrire dans son rapport de président sortant d'autres activités et initiatives visant à faire avancer l'égalité, la diversité et l'inclusion.

Dans le même ordre d'idées, je suis fier que le Congrès 2016 à l'Université d'Ottawa, qui amorçait ma présidence, ait accueilli la première conférencière Herzberg (Victoria Kaspi, de l'Université McGill) – première attendue depuis longtemps, faut-il dire – et qu'une deuxième conférencière Herzberg (Nergis Mavalvala du MIT) soit prévue au prochain Congrès de 2018 à l'Université Dalhousie, qui conclura mon année à titre de président sortant. Comme la conférence commémorative Herzberg est le principal événement du Congrès ouvert au public, la représentation des femmes et d'autres groupes sous-représentés est très importante; puisse cette tendance se poursuivre!

CAP Foundation. Those of you who have been around for more than a few years will remember the Education Trust Fund; perhaps you donated to it when you renewed your membership. The ETF has evolved into the CAP Foundation, the charitable arm of the CAP. The CAPF maintains the suite of initiatives supported in the past by the ETF (the Lecture Tour, prizes and medals, etc), and it does a whole lot more! Basically, the Foundation's goal is to finance activities and initiatives that help the CAP attain its strategic goals as they relate to promoting physics as a career and celebrating the achievements of Canadian physics and physicists.

In particular, the CAPF is putting a significant effort into raising the profile of physics in the eyes of the general public. The goal is to have parents feel that physics is every bit as prestigious a profession for their daughters and sons as medicine and law, and to have high school guidance counsellors encourage students who obviously like math and physics to go into physics (or engineering) rather than engineering (or physics). Two specific initiatives along these lines were producing (and distributing to every high school in Canada!) a poster whose theme was "Spot the Physicist" to highlight some interesting careers using physics training, and a series of short video profiles of physicists working in interesting, non-academic, professions. The videos are available on the CAP web site; you can also view them (and other videos) on the CAP youtube channel, named CAPhys, to which you should certainly subscribe!

The CAPF launched a fundraising drive entitled "Ignite the Spark" just prior to my year as president, and the drive was very successful. Nevertheless, in order for the Foundation to continue its work promoting physics, more funding is crucially important – and is currently being matched through a pledge from the Carswell Family Foundation. I encourage you to go to the CAP web site, and in particular to the CAPF page for further information, and to click on the Donate Now button to make a generous (tax-creditable) donation.

Membership Initiatives. As I hope is already clear, we have made many visible improvements, particularly in communications, which are designed to enhance our services to members and to the public at large. Other changes will be implemented with barely a ripple to our members and affiliates: a long-overdue replacement of our "Customer Relationship Management" software (fancy terminology for database), replacement of servers, and so on.

All these changes require resources, and we expect that an improved product will give the Association more appeal to physicists across Canada, both within and beyond academia, resulting in increased membership. Several initiatives to increase all flavours of membership have been or are about to be undertaken. For instance, for those of you

Fondation de l'ACP. Ceux d'entre vous qui sont là depuis plusieurs années se rappellent le Fonds d'éducation en fidéicommis (FEF); peut-être y avez vous fait un don en renouvelant votre adhésion à l'ACP. Le FEF est devenu la Fondation de l'ACP (FACP), organe caritatif de l'ACP. La FACP maintient la série d'initiatives que finançait le FEF par le passé (Tournée de conférenciers, prix et médailles, etc.), et elle fait d'ailleurs beaucoup plus! Essentiellement, l'objectif de la Fondation est de financer les activités et initiatives qui aident l'ACP à réaliser ses objectifs stratégiques relativement à la promotion de la physique comme carrière et à célébrer les réalisations de la physique et des physiciens au Canada.

En particulier, la FACP fait de grands efforts pour relever le profil de la physique aux yeux du grand public. L'idée est d'amener les parents à penser que la physique est une profession tout aussi prestigieuse que la médecine et le droit pour leurs enfants, et les conseillers en orientation au secondaire à encourager les étudiants qui aiment naturellement les maths et la physique à se lancer en physique (ou en génie) plutôt qu'en génie (ou en physique). Deux initiatives particulières en ce sens ont été de produire (et distribuer à toutes les écoles secondaires au Canada!) une affiche sur le thème « Trouver le physicien » afin de faire valoir d'intéressantes carrières reposant sur une formation en physique, et une série de brefs vidéos présentant le profil de physiciens qui exercent des professions intéressantes, non universitaires. On peut visionner ces vidéos, de même que d'autres, sur le site Web et sur la chaîne YouTube de l'ACP, appelée CAPhys, à laquelle vous devriez vous abonner, bien sûr!

La FACP a lancé, juste avant mon année à la présidence, la très fructueuse campagne de collecte de fonds « Allumer la flamme ». Néanmoins, pour qu'elle puisse poursuivre son travail de promotion de la physique, un financement accru est crucial – la Carswell Family Foundation égalant les sommes qui seront recueillies. Je vous encourage à aller sur le site Web de l'ACP et en particulier sur la page de la FACP pour un complément d'information, et à cliquer sur le bouton FAIRE UN DON généreux (donnant droit à un crédit d'impôt).

Initiatives concernant l'adhésion. Comme c'est déjà clair, je l'espère, nous avons apporté de nombreuses améliorations visibles, notamment en communication, qui visent à rehausser nos services aux membres et au grand public. D'autres changements seront mis en œuvre sans que la moindre ride ne trouble nos membres et affiliés : le remplacement attendu depuis longtemps de notre logiciel de « gestion des relations avec les clients » (terme fantaisiste désignant la base de données), le remplacement des serveurs, etc.

Tous ces changements exigent des ressources et nous espérons qu'un produit amélioré attirera davantage les physiciens de tout le Canada à l'Association, tant dans les universités qu'à l'extérieur, et permettra d'accroître les adhésions. Plusieurs initiatives visant à accroître les types d'adhésion sont sur le point d'être lancées ou le sont déjà. Par exemple,

in academia, your non-member colleagues should have been visited by your department's Friend of the CAP early in the 2017-2018 academic year to promote CAP membership.

The importance of YOUR help in getting the word out cannot be underestimated. I hope you feel the CAP does useful work. As I said in my address at the Congress at Queen's, in my opinion all Canadians, whether living in Canada or not, and all people living in Canada, whether Canadian or not, who self-identify as physicists should support the CAP, whose very raison d'être is to support them right back. Attracting more members is invaluable for two reasons. Most obviously, it of course gives us more resources. But less obviously but nonetheless importantly, it gives the CAP a stronger voice to advocate on behalf of physics in Canada. So please, be an ambassador for the CAP. It's your association, working for your good and that of physics more generally. Talk to your new colleagues, associates and students; tell them how important it is for them to join the CAP.

SUMMARY AND LOOKING AHEAD

As I said earlier, it was an eventful year for the CAP. Some of what made it eventful has been described above. But part of what made this year particularly challenging, in addition to major initiatives mentioned above, has been a reorganization of the office staff coupled with some unforeseen changes of personnel which had the staff in a bit of a train-and-retrain mode for much of the year. We seem to have settled down to a team who work very well together:

- Executive Director Francine Ford, who celebrated her 25th year with the Association in 2016, just prior to my presidency, providing much-needed stability as well as our "institutional memory";
- Membership Manager Chantal Éthève-Meek, another stabilizing influence who has been with us since Sept. 29, 2011 and who is heavily involved in our very important efforts to increase membership;
- Program Manager Ann-Marie Robertson, who will be ensuring that the CAP programs you have come to count on, as well as some new ones, will run smoothly;
- Communications Manager Gina Grosenick, whose communications insight and acuity have been absolutely invaluable over the last couple of years.

I thank them all for their dedication and devotion to the Association; it goes without saying that their hard work has been a critical element of the CAP's continued success.

I also want to express how much of a pleasure it has been to work with the unsung (and, more to the point, unpaid!) heroes of the Association: the Executive, the Board of Directors and the Advisory Council. It has been, and continues to be, inspiring to work with them all.

pour ceux d'entre vous qui êtes dans les universités, l'ami de l'ACP de votre département aurait dû rencontrer vos collègues non membres au début de l'année universitaire 2017-2018 pour promouvoir l'adhésion à l'ACP.

On ne peut sous-estimer l'importance de VOTRE aide à propager le message. J'espère que vous croyez que l'ACP fait œuvre utile. Comme je le mentionnais dans mon allocution au Congrès tenu à l'Université Queen's, je suis d'avis que tous les Canadiens vivant au Canada ou non, et tous ceux qui y habitent, qu'ils soient Canadiens ou non et qui se disent physiciens, devraient appuyer l'ACP, dont la raison d'être même est de les appuyer en retour. Attirer un plus grand nombre de membres est précieux pour deux raisons. Bien évidemment, cela procure plus de ressources, mais de façon moins évidente mais tout aussi importante, cela rend l'ACP plus forte à titre de porte-parole plaidant en faveur de la physique au Canada. Veuillez donc vous faire l'ambassadeur de l'ACP. C'est votre association et elle travaille pour votre bien et celui de la physique de façon plus générale. Parlez-en à vos nouveaux collègues, associés et étudiants; dites-leur à quel point il importe pour eux d'adhérer à l'ACP.

RÉSUMÉ ET PERSPECTIVES

Comme je l'ai dit plus tôt, l'ACP a connu une année riche en événements et j'ai exposé en quoi celle-ci a été si bien remplie. Mais un élément qui l'a rendue particulièrement difficile, outre les grandes initiatives mentionnées ci-dessus, a été la réorganisation du personnel de bureau, ajoutée à certains changements de personnel imprévus, qui ont fait que le personnel a été en mode formation une bonne partie de l'année. Il semble que nous soyons parvenus à constituer une équipe qui travaille fort bien ensemble:

- La directrice exécutive Francine Ford, qui a célébré sa 25e année à l'Association en 2016, juste avant ma présidence, ce qui a assuré une stabilité fort nécessaire et une « mémoire institutionnelle »;
- La coordonnatrice des adhésions, Chantal Éthève-Meek, autre facteur de stabilité qui est avec nous depuis le 29 septembre 2011 et participe beaucoup aux grands efforts visant à faire augmenter les adhésions;
- La chef de programmes, Ann-Marie Robertson, qui veille à ce que l'application des programmes de l'ACP, sur lesquels vous en êtes venus à compter, et de certains autres nouveaux, se déroule sans problème;
- La gestionnaire des communications, Gina Grosenick, dont la capacité d'analyse et l'acuité en communications ont été inestimables ces dernières années.

Je les remercie toutes de leur dévouement envers l'Association; il va sans dire que leur dur labeur a été un élément essentiel du succès constant de l'ACP.

Je tiens aussi à exprimer le grand plaisir que ce fut de travailler avec les héros oubliés (et, plus précisément, mal payés!) de l'Association : la direction, le conseil d'administration et le conseil consultatif. Ce fut et continue d'être inspirant de travailler avec toutes ces personnes.

Special thanks to my predecessor Adam Sarty (St. Mary's University), who went through it all a year ahead of me, so he was an invaluable advisor and sounding board for me.

As my term came to an end at the 2017 Congress, I passed the presidential hat (and the secret handshake, but that's another story!) on to Stephen Pistorius (University of Manitoba, CancerCare Manitoba, and Manitoba Institute of Cell Biology). I did so with absolutely no trepidation. Already at the first Board meeting under his presidency, Stephen initiated a process of restructuring the governance of the Association. I am convinced that under his leadership the CAP will make great strides toward its stated goal of achieving organizational and operational excellence. I am confident that the Association is in great hands, and I look forward to seeing the CAP flourish under the leadership of Stephen and of those who will follow in his footsteps, beginning with Bruce Gaulin (McMaster University) and then Shohini Ghose (Wilfrid Laurier University).

Je tiens à remercier mon prédécesseur Adam Sarty (Université St. Mary's) qui a connu tout cela un an avant moi, de sorte qu'il a été un conseiller inestimable et m'a fourni une précieuse rétroaction.

Comme mon mandat a pris fin au Congrès 2017, j'ai cédé le fauteuil présidentiel (et la poignée de mains secrète, mais c'est une autre histoire!) à Stephen Pistorius (Université du Manitoba, CancerCare Manitoba, et Manitoba Institute of Cell Biology). Je l'ai fait sans aucune fébrilité. Déjà à la première réunion du conseil d'administration sous sa présidence, Stephen a inauguré un processus de restructuration de la gouvernance de l'Association. Je suis convaincu que, sous sa houlette, l'ACP fera de grands pas vers la réalisation de son objectif avoué d'atteindre l'excellence sur le plan de l'organisation et du fonctionnement. Je suis convaincu que l'Association est entre bonnes mains et je brûle de la voir fleurir sous la direction de Stephen et des personnes qui marcheront dans ses traces, à commencer par Bruce Gaulin (Université McMaster) et Shohini Ghose (Université Wilfrid-Laurier).

The Editorial Board welcomes articles from readers suitable for, and understandable to, any practising or student physicist. Review papers and contributions of general interest of up to four journal pages in length are particularly welcome. Suggestions for theme topics and guest editors are also welcome and should be sent to bjoos@uottawa.ca

Le comité de rédaction invite les lecteurs à soumettre des articles qui intéresseraient et seraient compris par tout physicien, ou physicienne, et étudiant ou étudiante en physique. Les articles de synthèse d'une longueur d'au plus quatre pages de revue sont en particular bienvenus. Des suggestions de sujets pour des revues à thème sont aussi bienvenues et peuvent être envoyées à bjoos@uottawa.ca.

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The Canadian Association of Physicists cordially invites interested corporations and institutions to make application for Corporate or Institutional membership. Address all inquiries to the Executive Director at execdir@cap.ca.

L'Association canadienne des physiciens et physiciennes invite cordialement corporations et institutions à faire partie des membres corporatifs ou institutionnels. Renseignements auprès de la directrice exécutive au execdir@cap.ca.

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. You must be a residing in Canada to request a book.

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 2011 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 2011 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 LEVEL

Asteroseismic Data Analysis: Foundations and Techniques, (V) Sarbani Basu & William J. Chaplin, Princeton University Press, 2017; pp. 352; ISBN: 9780691162928; Price: 102.31.

Fashion, Faith, and Fantasy in the New Physics of the Universe, (V) Roger Penrose, Princeton University Press, 2017; pp. 520; ISBN: 9780691178530; Price: 37.95.

Welcome to the Universe: The Problem Book, (V) Neil deGrasse Tyson, Michael A. Strauss & J. Richard Gott, Princeton University Press, 2017; pp. 264; ISBN: 9780691177816; Price: 43.95.

SENIOR LEVEL

Fearful Symmetry: The Search for Beauty in Modern Physics, (V) A. Zee, Princeton University Press, 2016; pp. 376; ISBN: 9780691173269; Price: 24.02.

Modern Classical Physics: Optics, Fluids, Plasmas, Elasticity, Relativity, and Statistical Physics, (V) Kip S. Thorne & Roger D. Blandford, Princeton University Press, 2017; pp. 1552; ISBN: 9780691159027; Price: 136.10.

Book Reviews / *Critiques 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.

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.

200 More Puzzling Physics Problems by Péter Gnädig et Gyula Honyek, Cambridge University Press, 2016, pp. 480, ISBN 9781107503823, Price 33.95.

Those who enjoyed the 2001 "200 puzzling physics problems" should also enjoy this new vintage, with a full set of 200 new interesting physics problems, plus hints and solutions. Those who did not read the first edition should also find this latest version interesting and, as I was, be tempted to have a look at the 2001 edition. The book follows the same format as the first edition, with a first section on problem statements, another section giving hints for each problem, and for readers who, due to lack of time can't solve the problems, a section with full solutions. Problems are tailored around many topics of classical physics, including kinematics, dynamics, elasticity, electrostatics, and many more. The stated objectives of the book is to "teach and train student, and … intrigue and entertain everybody who likes physics ...". On my account the second objective has been brilliantly successful. The majority of problems can be solved with a little thinking, or by writing a few equations on the back of an envelope, using relatively simple mathematics. A few problems require the construction and solution of differential equations, but those are a minority. In my reading I spent relatively little time looking at hints and even less at full solutions. I enjoyed reading the book a few pages at a time, finding solutions without paper if possible, and when needed, by solving equations. My favorite problems are those that are not obvious at first sight, but that don't require any advanced tools to solve. Those are the clever and intriguing problems that a lay person, with no or modest formal training in physics could appreciate and enjoy. I don't know to what extent the new problems presented in this book can "teach and train students", but they can certainly contribute in stimulating their interest. I strongly recommend this book, along with the 2001 edition, to every undergraduate physics student, and more generally to everyone interested in strengthening his/her intuition in the workings of the basic physical laws of nature. The main value of the book is to challenge the reader already familiar with basic physics principles and mathematical methods, with relatively simple enigmas, and in so doing, help him/her develop better intuition and problem solving skills.

Richard Marchand
Professor of Physics, University of Alberta

A Lesson for the Future of Our Science: My Testimony on Lord Patrick M S Blackett by Antonino Zichichi, World Scientific, 2016, ISBN: 978-981-4719-41-4, price

My interest in this volume flows from having been a graduate student at the Blackett Laboratory of Imperial College 1964-1966, when Patrick Blackett [1897-1974] was a professor, including passing this distinguished physicist in the corridor on our floor, and attending a 2 week NATO ASI in 1981 at the Erice, Sicily, "Ettore Majorana" International Centre for Scientific Culture (ICSC), which uses restored convents and monasteries atop the mountain overlooking Trapani, where Zichichi was born in 1929. One aspect of Blackett's WWII contributions in developing the beginnings of Operational Research to help the wartime efforts is discussed in Chapter 5. This helped in the liberation of Malta which lies south of Sicily, and then of Sicily. Zichichi, a former student of Blackett, wrote this Testimony after being invited to give a lecture at ICSC in April 2014. He has been instrumental in the naming of the Blackett Institute at Erice and gives a well illustrated overview of Blackett's research contributions to particle physics, to his role in the development of scientific organizations, and to many illustrious thinkers that he (AZ) met along the way - especially "Professor Blackett and his friend Bertrand Russell". The latter, as well as Galileo, Gödel, Dirac, Einstein, Fermi, Occhialini, Planck, and Weisskopf are each indexed about twenty times. Zichichi suggests that Russell harboured the thought: *Physicists, that vile cursed race pf beings.* p. 80). This book contains a rich collection of information which should be useful in preparing an account of particle physics from the early days through to the Standard Model, especially with respect to the massive experiments at places like CERN involving hundreds or even thousands of personnel. Also Zichichi philosophises about "Our Science", including concepts such as the "1st level of Galilean Science". This book is at least as much about Antonino Zichichi as it is about Blackett. Finally, the reader should consult the current Wikipedia entries on Antonino Zichichi and on Blackett. The latter is particularly good.

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Classical Electromagnetism in a Nutshell, by Anupam Garg, Princeton University Press, 2012, pp. 712, ISBN: 9780691130187, price 144.00.

Teaching a graduate course on classical electromagnetism, one often encounters the difficult task of selecting books that are best for the course. First, there is the 'classic' book by Jackson that is best known world-wide, and then there are the others. The goal of Jackson's book is to provide a solid grounding with the mathematical rigor that is essential for the development of Maxwell's theory of electromagnetism. There is simply no other book that provides such a complete exposition of the topics, as one realizes that while struggling through the seemingly endless examples of the 'Boundary-value problems'! However, in that attempt, this book has become highly compact, and quite difficult for students to get past the endless mathematical steps and appreciate the inherent beauty and wide implications of this wonderful subject in modern-day life. Some of the other books have tried to complement Jackson by presenting even more mathematical details that are left as 'it can be readily shown' in the text by Jackson. Best examples include books by W. Greiner (Springer), B. di Bartolo (World Scientific), among others. However, the didactic value of those books are still laudable.

Anupam Garg's Classical Electromagnetism in a Nutshell takes a somewhat different approach. This book begins with a detailed account of vector calculus, Fourier transformation, and other essential mathematical techniques. Then the conventional topics of electrostatics, magnetostatics, time-dependent electromagnetic phenomena etc. are discussed in the usual fashion. However, the emphasis throughout has been to show their relevance in physics. In fact, this is the essence of Garg's book where advanced students can appreciate the importance of this old subject in the modern world. For example, in the section, 'Motion in crossed E and B fields' (Sect 71), a discussion, albeit inadequate, is given of the Hall effect that has been a major topic of research in condensed matter for several decades. Similarly, the Hanbury-Brown and Twiss effect, the Pancharatnam phase, or the Raman scattering are topics that are barely mentioned in a book on electromagnetism, but introduced in this book. There are many such topics scattered throughout the book that bring life to the dreary mathematical equations that precede these profound phenomena. The novelty of this book is in its description

of the application of electromagnetic phenomena in various branches of physics.

This 700 page tome is a fruit of hard labor by the author that can be a valuable reference book for advanced students. However, it is still not the book that will replace Jackson as the 'ideal' textbook, since that book is yet to be written. Nevertheless, this book provides a broader perspective of the old subject that might be beneficial for graduate students and even for beginning researchers.

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John Stewart Bell and Twentieth-Century Physics: Vision and Integrity by Andrew Whitaker, Oxford University Press, 2016, pp. 476, ISBN 978-0-19-874299-9, Price 52.50.

Une malédiction s'acharne-t-elle sur ceux qui, une génération après la découverte de la mécanique quantique, ont fait renaître l'analyse des fondements de la théorie? On connaît les démêlés de David Bohm avec le maccarthysme, qui ont conduit à la perte de son emploi à Princeton et à son exode des États-Unis. On sait peut-être moins qu'il a lutté contre des épisodes de sévère dépression, qui l'ont poursuivi jusqu'à la fin de sa vie. Hugh Everett III, fumeur compulsif, alcoolique et séducteur, a été terrassé par une crise cardiaque à l'âge de 51 ans. Par contraste, John Stewart Bell, le troisième géant du réexamen de l'interprétation de la théorie quantique, a eu une vie personnelle beaucoup plus tranquille: naissance à Belfast, en 1928, dans un milieu modeste; poursuite d'études grâce à quelques bourses et à l'encouragement de sa mère; mariage à 25 ans et vie conjugale heureuse jusqu'à son décès, prématuré doit-on dire, à 62 ans.

Comment donc écrire plus de 400 pages tissées serrées sur un personnage qui, d'un point de vue « people », présente peu d'intérêt? La réponse, évidemment, consiste à se concentrer sur l'apport scientifique du protagoniste. Whitaker nous le fait découvrir en détail, en le situant systématiquement dans le contexte de la physique du vingtième siècle.

La renommée scientifique de Bell vient surtout de deux articles assez courts qu'il a rédigés en 1964. Le premier réfute certaines « preuves » de l'impossibilité de variables cachées en mécanique quantique, en particulier celle que John von Neumann avait proposée 30 ans plus tôt. Le second, qui a reçu à ce jour près de 11 000 citations, montre l'incompatibilité de la mécanique quantique avec toute théorie locale et réaliste. Il n'est pas exagéré de dire que cet article, et les tests expérimentaux qu'il a inspirés, ont ouvert la voie à l'efflorescence de l'informatique et de la cryptographie quantiques.

Whitaker retrace l'intérêt de Bell pour les fondements de la théorie quantique à ses études de premier cycle à l'Université Queen's de Belfast. Très tôt, il est insatisfait des réponses de Bohr et du traitement que von Neumann réserve à la mesure. Il reconnaît, par contre, dès leur publication en 1952, l'importance des articles de Bohm sur les variables cachées. Mais il réalise également qu'il serait risqué, à ce moment, d'amorcer une carrière sur les problèmes fondamentaux de la théorie quantique. Toute sa vie, il en fera en quelque sorte son passe-temps, se sentant moralement tenu de consacrer la plupart de son énergie aux questions liés à ses emplois, à Harwell d'abord et, ensuite durant 30 ans, au CERN.

À travers l'aspect plus conventionnel des travaux de Bell, Whitaker nous fait découvrir un scientifique de premier plan. Les spécialistes de la théorie des champs connaissent les anomalies d'Adler, Bell et Jackiv, mais peu d'entre eux savent que Bell a obtenu de manière indépendante le théorème de l'invariance dans la transformation CPT. Ses travaux sur le « strong focussing » ont facilité la mise au point des premiers accélérateurs. Il s'est distingué par ses études sur les neutrinos, réalisées en collaboration avec Martinus Veltman. Celui-ci a d'ailleurs reconnu que des résultats de Bell ont préparé le terrain pour la preuve de la renormalisabilité des théories de jauge, développée par Veltman et Gerard 't Hooft au début des années 1970.

Whitaker décrit avec soin les institutions où Bell a œuvré. Son historique de la genèse du CERN est particulièrement intéressant. Le principal apport de l'ouvrage consiste toutefois en une analyse minutieuse des travaux scientifiques de Bell, constamment situés dans leur contexte. En un véritable tour de force, Whitaker réussit à présenter tous les concepts physiques pertinents sans jamais utiliser d'équations. Je ne sais pas à quel point les lecteurs qui n'auraient pas déjà vu les équations pourront s'y retrouver, mais on aurait peine à mieux relever le défi.

Sans doute, tous ne s'accorderont pas au jugement de Whitaker qui situe Bell à l'égal de Schrödinger, Heisenberg et Dirac. L'ouvrage nous fait néanmoins découvrir un physicien remarquable dont la rigueur, le sens des responsabilités et l'intégrité constitueront pour plusieurs une inspiration.

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The Art of Electronics – 3rd Edition by Paul Horowitz and Winfield Hill, Cambridge University Press, 2015, pp. 1224, ISBN 978-0-521-80926-9, Price 137.95.

The book's preface outlines its purpose as "an electronic circuit design textbook and reference book". At over 1200 pages it has the heft to cover those goals well. The first edition of this book was written in 1980, with the second edition coming in 1989. This third edition (26 years later) is not simply a small update to the second edition but almost a complete overhaul of the book. Some chapters were cut – notably scientific measurement and data processing – while considerably more have been added in. Most of the cut chapters and topics have been relegated to two companion books: "Learning the Art of Electronics" for more of the material relating to a lab course (for the second edition this book was titled "Student Manual for the Art of Electronics"); and "The Art of Electronics: The x-Chapters" covering advanced topics on BJTs, FETs, op-amps, etc. The added topics for this third edition include, among others, a chapter on computers, a nice chapter on logic interfacing including optoelectronics, and a much more detailed and updated treatment of microcontrollers. The list of topics covered is extraordinary and makes for an excellent reference textbook.

The text has a unique character to it in the way it presents the material. This involves copious amounts of footnotes, with genuinely interesting tidbits of information, that covers everything from the history of some part, to definitions of obscure words used, to interesting quotes. Each chapter has a review section that is great as a quick reference to the material covered within it. The index is also very detailed which is a necessity with a reference book.

Other unique sections in the book include many example circuits with nicely detailed explanations. They also include designs from manufacturers (called "Designs by the Masters") showcasing the reasoning behind the selection of the components used in a commercial product. Throughout the book the authors are able to convey their wisdom (which is vast) regarding the common pitfalls of circuit design and where to pay attention to the small details that may prove problematic. This is exemplified with the longest chapter in the book "Low-Noise Techniques", that covers how to deal with noise issues in a huge variety of situations and components.

After experiencing the benefit of having such a tome readily available as a reference, I am on the lookout for other textbooks that have the same great utility in other engineering and scientific subjects. I recommend the book for a wide variety of people, as it can be a benefit to any student or professional dealing with electronics that needs to know the finer details of how a particular part functions and works within a circuit. It is an excellent compendium for electronics in general and particularly for circuit design.

Tor Pedersen, Canadian Light Source

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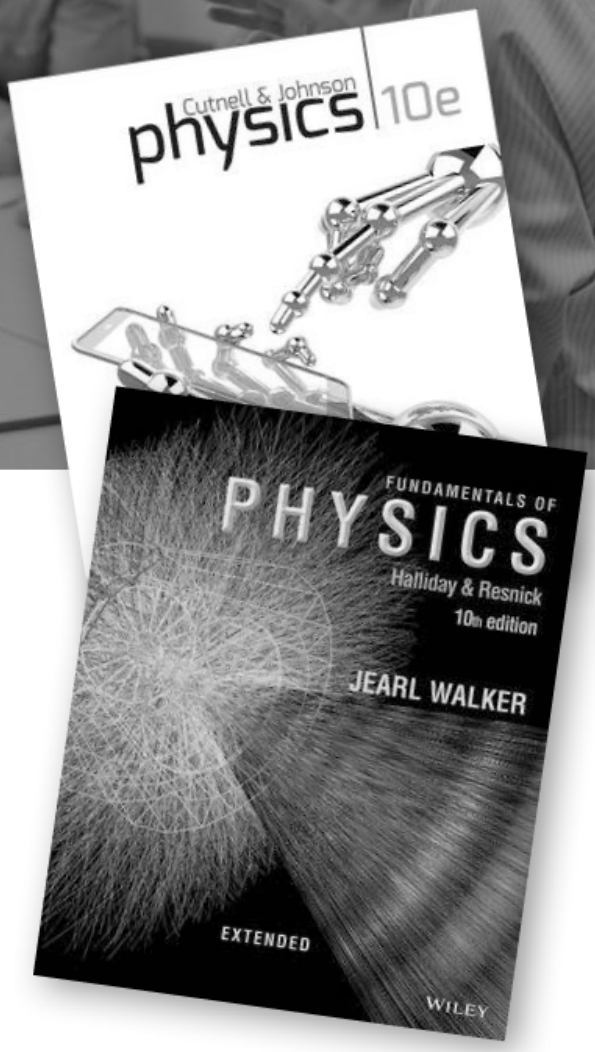

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