CAP-TRIUMF Vogt Medal for Contributions to Subatomic Physics

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

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

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

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

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

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

Dr. Akira Konaka

Remarks by Akira Konaka

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

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

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

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

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

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

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

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

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

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

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

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

CAP-CRM Prize in Theoretical and Mathematical Physics

Le Prix ACP-CRM de physique théorique et mathématique

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

Recipient of the 2016 Prize / Lauréat du prix 2016:

Dr. Freddy Cachazo

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

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

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

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

REMARKS BY FREDDY CACHAZO

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

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

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

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

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

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

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

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

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

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

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

CAP-INO Medal for Outstanding Achievement in Applied Photonics

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

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

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

Mr. Richard Boudreault

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

RF When did this start? Several years ago?

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

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

RF What do you see as the goal?

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

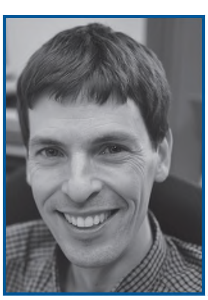
RF Are there any other thoughts in terms of recommendations for young physicists who are looking forward to the working world?

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

RF Thank you for sharing your insights with Physics in Canada

CAP Medal for Excellence in Teaching Undergraduate Physics

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



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

Prof. James Fraser

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

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

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

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

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

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

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

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

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

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

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

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

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

BJ: This was where, in Ottawa?

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

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

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

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

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

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

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

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

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

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

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

JF: Exactly.

BJ: [Chuckles] They're humungous.

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

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

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

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

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

BJ: They're so good these days.

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

BJ: Exactly, yeah.

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

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

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

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

BJ: And up-to-date or—

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

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

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

BJ: So this is an online quiz?

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

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

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

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

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

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

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

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

BJ: In class?

JF: In the tutorial.

BJ: Okay, during tutorial time.

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

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

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

BJ: You were her supervisor?

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

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

JF: It's not an official program.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

BJ: Excellent, thank you.

JF: Alright, so long.

CAP/DCMMP Brockhouse Medal

La Médaille Brockhouse de l'ACP/DPMCM

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

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

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

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

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

Prof. Carlos Silva

REMARKS BY CARLOS SILVA

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

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

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

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

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

CAP HERZBERG MEDAL

LA MÉDAILLE HERZBERG DE L'ACP

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

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

Prof. Roger Melko

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

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

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

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

Remarks by Roger Melko

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

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

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

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

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

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

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

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

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

CAP Medal for Lifetime Achievement in Physics

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

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

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

Prof. Gilles Fontaine

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

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

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

ENTREVUE AVEC GILLES FONTAINE, JUIN 2016 (PAR RENÉ ROY)

RR: Bonjour, Gilles

GF: Bonjour, René.

RR: Bravo encore une fois pour cette belle reconnaissance.

GF: Merci beaucoup.

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

GF: Merci beaucoup, René.

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

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

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

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

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

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

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

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

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

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

RR: Mes félicitations pour cette réussite.

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

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

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

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

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

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

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

RR: Tu as raison d'être fier.

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

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

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

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

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

RR: La relève.

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

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

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

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

Comment ça s'est passé dans ton cas?

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

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

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

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

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

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

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

RR: Ce dernier est-il toujours opérationnel?

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

RR: Est-ce le plus grand en Arizona?

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

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

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

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

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

RR: Comment la prédiction avait-elle été faite ?