Interactions

Message from the Chair

Welcome to the Fall 2016 issue of Interactions, the Department of Physics newsletter. In addition to news about the Department, we have profiles of two faculty members, Aephraim Steinberg (page 4) who is one of the world's leading experts on the foundations of quantum mechanics and Amanda Peet (page 6) who is doing pioneering work on string-theory approaches to the physics of black holes. One of the amazing things that happened last year was the observation by LIGO of the gravitational waves produced by the collision of two black holes, and on page (pg 13) Ph D student Heather Fong, who is a member of the LIGO consortium, tells how she got into gravitational wave research.

You can also read about Madeline Bonsma (pg 8) who has won a prestigious Vanier Award (pg 1) to apply theoretical physics techniques to evolutionary biology, and about Kevin Roy (pg 9) who is modelling how the Earth's surface is rebounding following the lifting of the weight of the ice sheets from the last ice-age.

We have many wonderful alumni, and on page (pg 7) you can read about Josef Kates' amazing journey from childhood in Vienna to the Chancellorship of the University of Waterloo and Chair of the Science Council of Canada, via the University of Toronto Math and Physics program in the 1940's and a PhD in physics in 1951.

On page (pg 3) you will find an invitation to the upcoming Tuzo Wilson Lecture, on Thursday November 3 at 8:00 p.m. in the Isabel Bader Theatre. The speaker is Susan Lozier, and she will talk about recent progress in understanding the complex interaction of the ocean with climate, which is one of the most important questions in all of science, because it has important implications for climate change. Please come! Also, everyone is welcome to attend our weekly physics colloquia, where ground-breaking results are described in a way that is accessible to anyone with a physics background. The schedule is here. You are also welcome to the coffee and cookies, served in the Graduate Lounge, before the colloquium. Finally, we are grateful to all of the alumni who participate in our mentorship program (pg 15), but we can always use more! Please get in touch with Sheela if you have time and the inclination to get involved. A little bit of your time can make a big difference to one of our students.

Yours Sincerely,

Stephen Julian

In this issue:

2016 Vanier Award Recipient - Graduate Student Madeleine Bonsma

Graduate student Madeleine Bonsma has become the first woman in our Department to receive a Vanier Award.

The Vanier Canada Graduate Scholarships (Vanier CGS) Program is administered by the Vanier-Banting Secretariat (Secretariat) on behalf of Canada's three granting agencies: the Canadian Institutes of Health Research [CIHR], the Natural Sciences and Engineering Research Council of Canada and the Social Sciences and Humanities Research Council of Canada.

The Vanier CGS Program aims to attract and retain world-class doctoral students by supporting students who demonstrate both leadership skills and a high standard of scholarly achievement in graduate studies in the natural sciences, engineering, social sciences and humanities, or health sciences.

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A Vanier CGS is valued at $50,000 per year for three years.

Madeleine did her Masters and is doing her PhD with Professor Sid Goyal in the area of Biophysics and she also won the NSERC Gilles Brassard Doctoral Prize for Interdisciplinary Research valued at $10,000 this year. Please see page 8 For a full profile on Madeleine.

Past holders of the Vanier Award from our Department are:
Patrick Jean-Ruel, Hubert De Perio, Juan Nicolas Quesada Mejia and Edouard Harris.

Message from the Associate Chair of Undergraduate Studies

I am honoured and excited to take over as the undergraduate chair for the next three years. The third floor has been welcoming, and I feel especially lucky to have the assistance of Teresa Baptista, whose many years of knowledge and hard work are helping with the transition.

I spent my undergraduate years in this very department, graduating in 1993 with a B.Sc. in Physics and Astronomy. At the time, this office was occupied by Nigel Edwards. After a year working at the Dunlap Observatory, I moved away and then re-joined the department in 2004 as a Lecturer. Since Nigel, this position has been filled by many of my esteemed colleagues: David Bailey, Stephen Morris, Paul Kushner and most recently, Sabine Stanley. I have big shoes to fill.

My appointment marks the first time a teaching-stream faculty member has served as undergraduate chair in this department. Hopefully, I will bring to bear my experience with the big first and second-year courses, and how things run in the undergraduate labs, for the betterment of our students.

The biggest change on the horizon is a major renovation planned for the North Wing, starting in December of this year. Expect to see a transformation of the first floor, and parts of the second floor, as we upgrade our first- and second-year laboratories, the space for our Physics Learning Services technologists, and the addition of a new undergraduate lounge facing the Chemistry building. This lounge will feature a new entrance to the building when approaching from the North. The target for completion is August 2017!

Yours Sincerely,

Jason Harlow

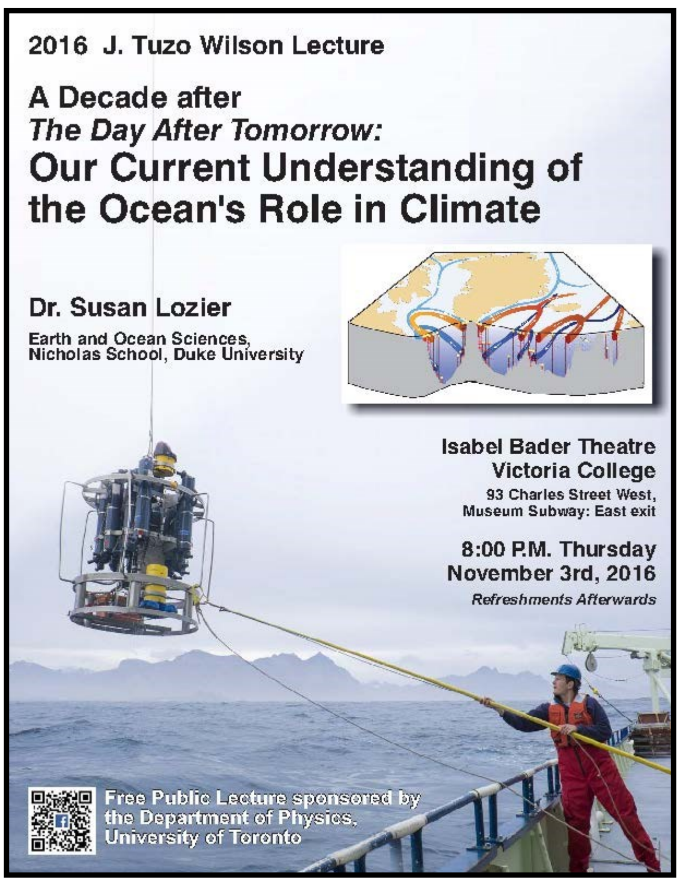
Your invitation to the 2016 Tuzo Wilson Lecture

Thursday, November 3, 2016
8:00pm
Isabel Bader Theatre - 93 Charles St W, Toronto, ON M4Y 1V2

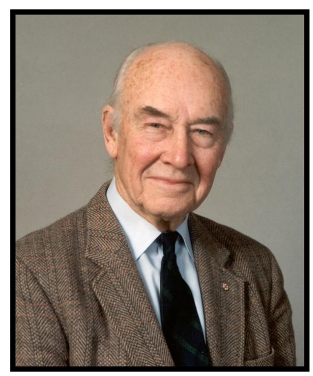
A Decade after *The Day After Tomorrow:* Our Current Understanding of the Ocean's Role in Climate

Susan Lozier
Earth and Ocean Sciences, Nicholas School, Duke University

In 1800 Count Rumford ascertained the ocean's meridional overturning circulation from a single profile of ocean temperature constructed with the use of a rope, a wooden bucket and a rudimentary thermometer. Over two centuries later, data from floats, gliders and moorings deployed across the North Atlantic has transformed our understanding of this overturning circulation, popularly termed the ocean 'conveyor belt'. While Rumford appreciated the role of the ocean's overturning in redistributing heat, today we understand the crucial role that this circulation plays in sequestering anthropogenic carbon dioxide in the deep ocean. In this talk I will discuss our current understanding of the ocean's overturning circulation, its role in our global climate and what we currently do and don't understand about the mechanisms controlling its temporal change.



The annual Tuzo Wilson Lecture commemorates the life and work of J. Tuzo Wilson (1908-1993), one of the great earth scientists of his time, and one of the founders of Geophysics in Canada.



Wilson made decisive contributions to the revolution in the Earth Sciences brought about by the establishment of the plate tectonics paradigm in the '60s and '70s.

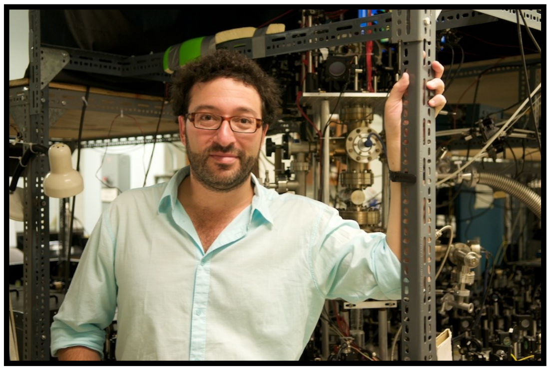
The J. Tuzo Wilson Professorship in Geophysics was established in 1995 in his honour.

Faculty Profile

Aephraim Steinberg

Professor

Quantum Physics



Why did you decide to become a physicist?

It was less a decision than a fait accompli. My dad, an electrical engineer, used to try to explain things to me and my questions invariably slipped from his "how" to the physicist's "why." Maybe I'd understand transistors better today if I'd just listened to him instead of getting hung up asking him WHY two electrons couldn't be in the same place. But I have to admit that Star Trek played a role too. The first time I heard the word "physics" was when someone informed me that that's what I'd have to learn if I wanted to know how to design a safe trajectory for a spaceship to re-enter the atmosphere along (Hmm... I see I've had an attachment to "trajectories" for longer than I'd realized before trying to answer this question; see question 4 below.)

Honestly, I spent much of university trying to see if there was anything else that interested me more than physics, and while I found lots of other interesting stuff, nothing ever got me to change my major. But I want to stress, for the students, that the other stuff was useful to me too. Maybe nothing so much as joining the Political Union (a glorified debating club), which got me over my terror of public speaking, so much more a part of this career than any one ever warned us at the time!

Your specific interests are quantum-mechanical phenomena and quantum states, why did you pursue this interest and what drew you to it?

Again, it hardly feels like it was a choice. I mean, I was always curious about black holes, and antimatter, and all the other "flashy" topics, as much as any other student, but deep down, I always just looked for the questions where no one knew "why?". Watching Nova programs about the quark model and so forth were fascinating, but in the end, it was just kind of like botany, only more interesting! (Apologies to my botanist friends as well as the particle physicists –- I'm half-kidding, of course.) When I learned (from a pretty off-the-wall science fiction book) about the EPR "Paradox" and Bell's Inequalities, I realized I'd come up against something where no one even understood why the RULES were the way they are, not just what the ingredients happened to be. That is still the feeling that drives me.

Tell me about your two-pronged experimental approach.

Let me instead say that in the end, any career owes so much to individuals you meet and work with along the way. I had an amazing mentor as an undergrad, Ed Hinds. Working in his lab changed my view of experimental physics, opening my eyes to things like cavity QED, laser-cooled atoms, and the possibility of testing fundamental physics (such as time-reversal symmetry) with atoms and photons. Thanks to Ed, I got to know Serge Haroche and work in his lab; and thanks to that experience, I got to join Ray Chiao's group at Berkeley. Ray's group was at the forefront of working with entangled photons, meaning that I got to do what I would never have dared to dream 7 or 8 years earlier, and work on Bell-Inequality experiments and other similarly fundamental topics. Worried in 1994 that down-conversion experiments may have run their course (in case you don't know, they're going stronger than ever 22 years later, and some still argue that they will form the basis for powerful quantum computers), I decided that for a career in physics I'd better learn more than one "trick," so I moved to Elisabeth Giacobino's lab and then to Bill Phillips's because I believed that laser cooling was the other most fascinating topic in AMO physics (which had, willy nilly, become my field). I still think it's important for young physicists to become experts in a few different areas, and stay open to new ideas.

Having these two "prongs," in particular, has positioned us to be among the groups trying to break new ground by studying "nonlinear quantum optics," where atoms mediate strong interactions between individual photons.

In 2011, you and your team were awarded Physics World 2011 Breakthrough of the Year for your work on the fundamentals of quantum mechanics, that sounds cool. What was the breakthrough?

That was an exceedingly gratifying (and surprising) honour, though the word "breakthrough" may be misleading. We used a technique known as "weak measurement," which I strongly believe provides a fascinating new perspective on many issues in quantum mechanics, to try to track the "average trajectories" of photons in a 2-slit interferometer (see my earlier remarks about Star Trek...). The conventional wisdom says you can't measure where something is and how fast it's moving, but weak measurement allows you – at least on average – to

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measure how fast particles at each position are moving, and thus build up these average trajectories. As Howard Wiseman had predicted, they turned out to reproduce exactly the picture you'd get from Bohm's fully deterministic interpretation of quantum mechanics, which I still think is pretty fascinating.

Some of your research involves cold atoms, why do you think so many scientists today are studying cold atoms? What is their potential for quantum information?

The word "cold" sometimes doesn't seem very dramatic, but the importance of this phrase is that these are atoms from which we've removed essentially all the random (thermal) motion, so that we can control and probe exactly what they are doing, with exquisite precision. (People get more excited about "high" energies and temperatures, but perhaps it's sobering to think that on a log scale, the energies we are talking about when we say "ultracold" are about as far away from room temperature as are CERN and the Higgs boson – only in the opposite direction.) Using cold atoms rather than room-temperature ones is the scientific equivalent of using laser beams instead of candlelight. One wonders what happened to the optical physicists in the 60s who thought that lasers were just a fad, and chose not to jump on the bandwagon!

Some of the original motivations for cold atoms involved building the most precise atomic clocks imaginable, and other applications have included ultra-sensitive accelerometers, gyroscopes, and gravimeters. But this degree of control also allows one to store quantum information in atoms and try to build logic gates out of them for a universal quantum computer. An alternate approach is to use these many-body systems to perform "quantum simulations" of other interacting systems, such as high-Tc superconductors.

Some of your research projects involve entangled photon pairs, what is the "two-photon" switch and how is it used in quantum information applications?

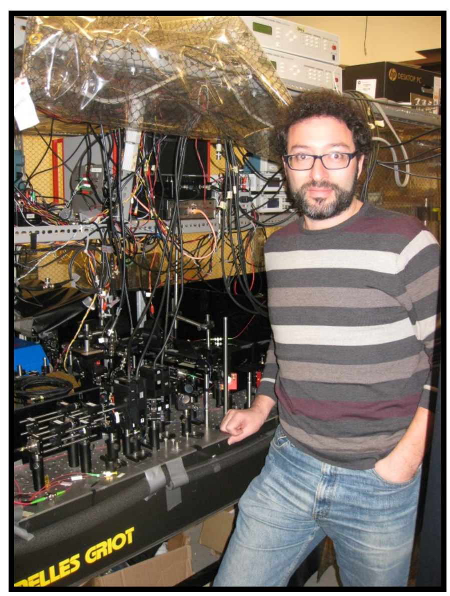
If we could build an ideal "switch" in which the presence or absence of one photon changed which way a second photon went (without either photon being destroyed, or for that matter "measured"), this would allow us to build quantum computers out of light – it's been established that there are tasks such a computer could solve exponentially more efficiently than any known (or envisioned) classical algorithm. At the moment, there are a number of candidates coming closer and closer to this remarkable goal. Given that normally, photons pass right through one another without a care in the world, and that in traditional nonlinear optics, one needs billions of photons in a pulse before there is any significant interaction, this is a dramatic change which promises to open up a new field of optical physics, whatever the impact on computation.

In May of this past year, your graduate students spotted a new magneto-optical trap in your lab. Can you tell us a little more about that and the significance.

We've been laser-cooling Rubidium atoms continuously in our lab since 1997, and the first apparatus we built for doing this finally gave up the ghost last year (a vacuum pump died in a rather inconvenient place). We took this as an excuse to upgrade and update what had become an unwieldy system, never really designed for what we now do with it. Sadly, we had just completed a really exciting experiment on quantum-level nonlinear optics we could do using those atoms, and had a number of follow-ups planned. But happily, our new group of students has made great progress, and since May, we've had a sparkly new magneto-optical trap (MOT) with a few hundred million Rubidium atoms, probably around 100 microkelvin above absolute zero, waiting for us to shine photons at them.

What is cool and exciting that is happening right now in your lab?

Well, as I said, we're about to be up and running again on our "quantum light-matter interactions" project; and we've been looking at Bose-condensed atoms tunneling through a focused beam of light, where very soon we should be able to start measuring how long atoms spend in a forbidden region they're tunneling through (something I've been talking about for 20 years, but which it has taken several generations of students to develop the tools to really probe in the lab); and there are a few quantum information projects underway. But for me maybe the most exciting recent development was that we took a detour into doing some classical imaging. A colleague of ours, inspired by quantum information, figured out that there is a way to beat the Rayleigh limit for image resolution, just by paying attention to phase information that we usually discard. We found a very simple way to implement this idea, and proved experimentally that we could use it to improve image resolution. It's nice once in a while to do something completely different, relatively simple, and hopefully actually useful! (Now we can go back to thinking about the quantum world again.)



Aephraim Steinberg in his lab

Faculty Profile

Amanda Peet

Professor
Theoretical High Energy Physics

Ever since you were a child, you have looked at the world through the eyes of a scientist. Can you tell me a little a bit about why that is, what inspired you to become a physicist?

One factor was the influence of my parents, who are both educators with science degrees. As kids, we were all encouraged to be curious about the natural world, regardless of gender. Another factor was liking schoolwork and having some great teachers. My favourite was Mr H, who taught me high school general science when I was 15. Noticing that I had finished the textbook near the start of the year, he pulled me aside after class one day and made me a deal. If I would keep my hand down and let the other kids answer his questions in class, he would let me ask him anything I wanted about science one day a week after school! He was true to his word, and gave me Scientific American articles on topics ranging from Earth's geodynamo to SU(5) particle physics unification. I was hooked.

At Stanford, where you did your PhD, your interests were String Theory and Black Holes, why were these two things are so fascinating?

Black holes are interesting because they have immensely strong gravity: studying them is like doing extreme sports. They arise naturally when big stars run out of gas and undergo violent collapse. The end result is a gravitational field so strong that even nearby light cannot escape. Four decades ago, Stephen Hawking posed a fundamental puzzle about black holes and loss of information that falls into them that researchers are still struggling to resolve today. Figuring it out hinges on upgrading Einstein's theory of gravity to a quantum theory of gravity.

String theory was invented in the late 1960s (like I was). It is interesting because it aims to uncover the underlying operating system of the universe. While building a killer app in a particular branch of physics is also a grand goal, string theorists strive to build a unified quantum framework for gravity and the other three forces, along with all matter particles acted on by them. Two waves of progress starting in 1984 and in 1995 laid the foundations for my current research program at the nexus between string theory and black holes.

You are a string theorist, can you tell our readers little a bit about what you do?

String theory is a part of theoretical subatomic physics. We use similar sets of tools as particle theorists, who aim to explain data from big experiments like the Large Hadron Collider. Specifically, I research two interrelated themes in gravitational string theory: microscopic modelling of black holes in the context of the information paradox, and holographic dualities between string theories in Anti de Sitter (AdS) spacetime and conformal field theories (CFTs) in one lower dimension. I really enjoy teaching as well as research. In 2007-8, I created a PMU199 course from scratch, to bring an appreciation of modern physics concepts including string theory to curious first-year undergrads who do not intend to major in science. Teaching it has been one of the biggest joys of my academic career.

Tell me about how you relate string theory to LEGO! That sounds really cool.

When we are taught atomic structure in high school, we are encouraged not to question the idea that point particles are the most elementary constituents. After all, what could be more indivisible than a point? Like every other assumption about how we model the natural world, this assumption deserves to be questioned.

String theorists propose using a better set of LEGOs known as fundamental strings. These are not the kind of string that your kitten plays with. They are extremely tiny, smaller than humans can currently resolve. Different subatomic 'particles' correspond to different vibrational patterns of one underlying versatile type of string, like different musical notes making up a symphony of nature. The lowest musical note of an open string provides the photon, which makes up light, while the lowest musical note of a closed string provides the graviton, a tiny ripple in the fabric of space-time.

How is all of this related to black holes?

Building things out of strings is not all that different than building them out of LEGOs. String theorists are not yet able to build you fully realistic worlds. But we can build you some pretty realistic models of aspects of the real world. These intricate models have lots of moving parts, and they go part-way to explaining the fully complex cosmos we strive to understand.

Black holes are made of matter and gravity, which are in turn made of strings. If we really think we understand string theory, then we ought to be able to explain properties of black holes. For some limited special types of black holes in various dimensions of space-time, gravitational string theorists have made real progress towards understanding the microscopic origin of their thermodynamic entropy and Hawking radiation. There remains much to be understood.

In February 2016, LIGO detected gravitational waves for the first time. Can you tell me little a bit about why this was so significant to physicists?

It mattered so much because it was the first strong-gravity test of Einstein's general theory of relativity. Gravitational waves were predicted a hundred years before they were discovered by the LIGO team in September 2015. It took the

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researchers until February 2016 to be sure that their detection was not a statistical fluke. An astonishing amount of scientific care and rigour went into the announcement. The discovery heralded the dawn of gravitational wave astronomy, a new window on the universe.

Finally, what was your reaction when you heard that first "chirp" from the colliding of black holes?

I admit, I cried tears of joy. I suspect every gravitational physicist on the planet was thrilled, right down to their bones. It was so exciting that I turned on the live feed in my Quantum Field Theory II classroom that day to let my students and me watch history being made.

Alumni Profile - Josef Kates

Josef Kates (formerly Katz), B.A., M.A., Ph.D., P.Eng., created the first digital arcade game called Bertie the Brain and showcased it at the Canadian National Exhibition (CNE) in 1950 while he was still working to complete his Ph.D. in Physics. He designed the game to demonstrate the function of the Additron Tube, another one of his inventions, which reduced the size of binary calculations in computers. Kates was always interested in computers but, as he explains, there was no such thing as computer science as a discipline at the time.

Born in Vienna on May 5th, 1921, Kates and his family arrived in the UK to escape the Nazis only to be interned in a UK camp in June 1940, then sent to Canada. While in the internment camp, he took the junior and senior matriculation course of McGill University in Montreal. In 1941, he graduated as the highest-ranking student in all of Quebec, even beating out Walter Kohn who would go on to receive the Nobel Prize for Chemistry in 1998. Kates said that he teased Kohn, later joking that it should have been his Nobel Prize. After his release from the internment camp, Kates moved to Toronto where, in 1944, he joined the University of Toronto (U of T) Mathematics and Physics program (also called M&P), graduating with honours in 1948, then completed his M.A. in Applied Mathematics in 1949, and lastly received his Ph.D. in 1951.

During the final years of Kates' Ph.D., he and his partner, Alfred Ratz, led the team that designed and built UTEC (University of Toronto Electric Computer), one of the first working computers in the world. Together, they were called "Katz and Ratz". Kates was in charge of designing the memory and control system of the computer, so he noticed how many tubes were needed to do adding for binary addition. The binary system contains only ones and zeros so to do binary addition it took about ten tubes. A problem solver, Kates was determined to create a smaller tube that was a tiny fraction of the size of ten tubes combined. The result was his invention of the Additron Tube.

Kates then brought it to his former manager, Mr. Van Dyke, at Dutch Philips Co. (now commonly known as Philips) who saw the monetary value of such an invention but the question remained on how to showcase the tube. Kates had the idea to design an arcade game that would play tic-tac-toe and exhibit the final product at the 1950 CNE. Mr. Van Dyke agreed to build the game, and together he and Kates dreamed that they would make billions if they could market the Additron Tube. Bertie the Brain was a huge success and drew in large crowds and long lines, with special appeal to children.

To make the game more interesting, Kates included a switch on the back so the level of difficulty could be set to easy, moderate and difficult. The highlight of the exhibit was when actor Danny Kaye, the Star attraction at that year, came to play the game. As Kates explains, "Danny was beaten over and over, and so he started hamming it up drawing in a larger crowd. He was a wonderful comedian!" So Kates lowered Bertie the Brain's intelligence until Danny won and proceeded to do a "dance of joy because he beat the first arcade game in the world!" In those days, Kates dreamed of becoming a billionaire through the Additron Tube profits because it reduced the size of computers by ten to one. Unfortunately, his dreams faded away when solid state devices came out that made use of the electronic properties of solid semiconductors and reduced the size of computers by millions to one.

After graduating from U of T, Kates began a long career that focused on designing and developing systems. In 1954 he founded and became president of KCS Ltd. (Kates, Casciato and Shapiro), which specialized in the application of computers to a wide variety of business and public organizations across the world. Kates also installed the first IBM computer in Toronto which became Canada's first computer service bureau. Incidentally, IBM became his biggest direct competitor even though he was the first IBM computer customer in Canada. In 1966, his company merged with another consulting firm to become Kates, Peat, Marwick & Co.

Danny Kaye with Bertie the Brain

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Kates also computerized Canada's first Medicare system to process medical claims at computer speed for the Government of Saskatchewan. Kates is still the president of Teleride/Sage Ltd. founded in 1977.

Kates' proudest moment, however, was when he was the Chancellor at University of Waterloo and presented the Premier of Ontario, Bill Davis, with an Honorary Degree in 1984. A large framed photo of the event hangs proudly in his living room. In the early 1950s, Kates was lucky enough to be one of about a hundred guests invited to attend Albert Einstein's birthday party. Another highlight was when in 1968, Prime Minister Pierre Trudeau appointed Kates to the new Science Council of Canada, a small Canadian governmental science advisory board that ran from 1966 to 1993. He became the chair in 1974. Trudeau also invited him and ten other scientists from Canada and the USA to a private dinner at 24 Sussex Drive.

Today, Kates continues to tackle public transit issues and has offered his expert advice to the TTC on how to reduce congestion on the Yonge Subway by using the abandoned Bay Lower station (http://bit.ly/2dCh8up), or through his more recent and simpler solutions called KCS (Kates Congestion Solution). Finally, Kates' one piece of advice to students is "always work hard" because physics is a difficult degree. Even in his ninety-sixth year, Kates continues to live by this rule.

Josef Kates was interviewed by Jacqueline Bennett for this article.

Are you an alumni who wants to share your career story? Get in touch at 416-978-3307 or email: newsletter@physics.utoronto.ca.
We would love to hear from you!

Graduate Student Profile

Madeleine Bonsma
PhD
Biophysics

Madeleine Bonsma is entering her second year as a PhD student in Dr. Sid Goyal's group, where she studies how bacteria and viruses interact with each other and evolve. Bacteria are waging a constant war against viruses, and bacteria have evolved many ways to deal with the virus threat. The subject of Madeleine's research is one particularly amazing bacterial defense system called CRISPR. CRISPR is an adaptive immune system – just like antibodies in our immune system, bacteria with CRISPR systems can remember and learn from past virus attacks. They do this by sampling small pieces of DNA from invading viruses and storing them in their own DNA; then, the next time a virus comes around, these bacteria can efficiently recognize and destroy the virus based on their immune "memory".

CRISPR research took the world by storm in 2013 when CRISPR-associated (Cas) proteins were first used as a genome-editing tool. However, Madeleine's research is concerned with how bacteria use their CRISPR systems in their natural environments, including the human body. Our bodies are packed with bacteria, and how these bacterial communities affect our health is not well understood. Two people can both be healthy, yet be host to vastly different microbiomes (bacterial communities). Madeleine hopes that studying the CRISPR system can shed light on how bacteria interact with their virus predators and each other, telling us more about how microbiomes are structured.

Madeleine completed an undergraduate degree at the University of Waterloo in physics, choosing physics because she had always been fascinated with astronomy and plant biology and wanted to avoid becoming a doctor.

On co-op terms she did research in ground-penetrating radar, quantum optics, materials science, and neuroscience. It was only when she arrived at the University of Toronto for a master's degree that she made the switch to biophysics, and she hasn't looked back. Biophysics combines the tools and mindset of physics with the most incredible phenomena in the universe, a perfect fit for someone who loves quantitative science and is fascinated by biology. The University of Toronto physics department has many people who are excited about problems in biology and are pushing the limits with new approaches from physics, making it a great place to study problems that bridge traditional disciplines.

Madeleine discovered by a happy accident a passion for programming and open science. She exercises both through UofT Scientific Coders, a group she founded in 2015 for graduate students and researchers to teach each other coding and research skills.

When she isn't frowning at her computer screen, Madeleine likes to read novels, run long distances through Toronto's trail system, admire her collection of potted plants, and dance to hip-hop music.

Graduate Student Profile

Keven Roy

PhD
Atmospheric and
Planetary Physics

Keven Roy is a PhD student with Professor Dick Peltier in the Earth, Atmospheric and Planetary Physics group. He is from Quebec City, and completed his undergraduate studies in Physics at McGill University in Montreal.

Keven has always been passionate about physics, and although his first research interests during his time at McGill were in astrophysics, he quickly became very focused on understanding the evolution of our home planet and how humans are now impacting it.

He chose the Department of Physics at the University of Toronto for his graduate studies because of the diversity of topics being researched here, as well as the strong expertise in geophysics and climate change science.

His research focuses on understanding how past large changes in ice sheet cover have left their mark on the Earth system, not only by changing the volume of the oceans, but also by depressing and raising its solid surface under these varying surface loads (a process that is impacting coastline evolution to this day). More specifically, he uses new observations of past sea levels from various coastal regions around the world (in particular, along the U.S. East coast) to develop the next generation of models of this process, called glacial isostatic adjustment (GIA).

He finds the topic very interesting and topical, given how this knowledge enables us to better understand past climate conditions and sea level change on the planet, as well as giving us a better understanding of the human impact on present and future sea level change.

In his free time, Keven likes to rock climb and get involved in various outreach activities promoting climate change awareness to the public.

Welcome to our new graduate students!

On September 7, the beginning of the term party and jamboree were held, the Department welcomed almost 50 new graduate students.

Please see the photos from the party on the right

Undergraduate Student Profile

Ramanjit Sohal

Physics Specialist

Why did you decide to major in Physics? What was your inspiration?

I have always enjoyed academic subjects in general. In elementary school, after having read many popular science books, I eventually settled on studying physics as I wanted to understand nature at the most fundamental level. So I have been set on studying physics for some time, although the reasons for my interest in the field have developed somewhat. In particular, once I started studying physics in earnest at university, what really appealed to me was the ability of physics to provide quantitative descriptions of complex systems and how seemingly unrelated phenomena can be described by similar theoretical frameworks.

What do you enjoy most about the physics program?

I really benefited from being able to learn about advanced topics and get a more nuanced understanding of different physics subfields by working with faculty and graduate students on research and reading projects. These opportunities helped me narrow down my research interests. Additionally, I enjoyed discussing coursework and physics in general with friends as most of my learning was cemented in these discussions.

What other extra-curricular activities are you involved in during your degree?

In first year I tried kendo but in subsequent years I did not participate much in extra-curricular activities as a result of heavier course loads and participation in research projects. I have also competed with friends in the University Physics Competition in which we met with some success. Outside of physics I enjoy reading, particularly history, science-fiction, fantasy, and classic literature.

What are your research interests?

I am interested in theoretical condensed matter physics. I find the variety of research directions and theoretical tools used in the field, as well as how closely theorists and experimentalists work together, very exciting. My experience in the field so far has been limited to topological materials, but I am open to exploring other topics as well.

What is your favorite course and why?

My favourite course would probably be PHY479 as it gave me an opportunity to get acquainted with modern topics in condensed matter physics as well as conduct some independent research.

What are your future plans?

I will be starting my PhD at the University of Illinois at Urbana-Champaign this Fall.

Where do you see yourself in 10 years?

Hopefully I will have my PhD and be somewhere along the path towards a career in physics academia.

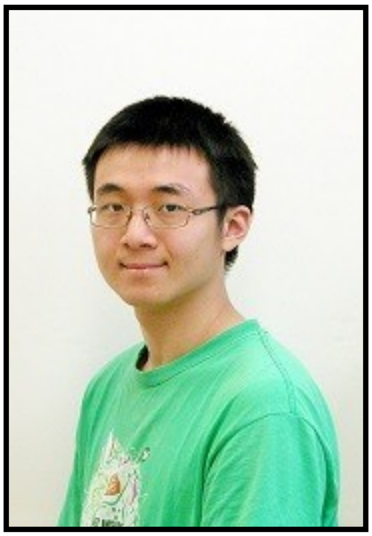
Tell me something interesting about yourself.

I am fairly good at making origami.

Undergraduate Student Profile

Chris (Yuan Qi) Ni

Math and Physics Specialist, Astronomy and Physics Specialist



Why did you decide to major in Physics? What was your inspiration?

I think it's incredible that humans can sit on a rock in space and come to the conclusion that the universe is 13.8 billion years old.

What do you enjoy most about the physics program?

I like to see subtle physics exploited in fascinating ways to generate mind boggling results. Like how the initial composition of the universe was decided in the first three minutes as a consequence of basic microscopic physics.

What other extra-curricular activities are you involved in during your degree?

I am involved in some outreach activities, and research in astrophysics.

What are your research interests?

I had a supervisor who once told me that anything when studied deeply enough is fascinating. It's only now, having touched a couple of different research topics, that I'm really starting to feel the impact of this statement.

What is your favorite course and why?

My favorite course so far is AST320, theoretical astrophysics. It is here that I came to appreciate the full scale of the descriptive power of physics because the derivations in this course are so powerful.

What are your future plans?

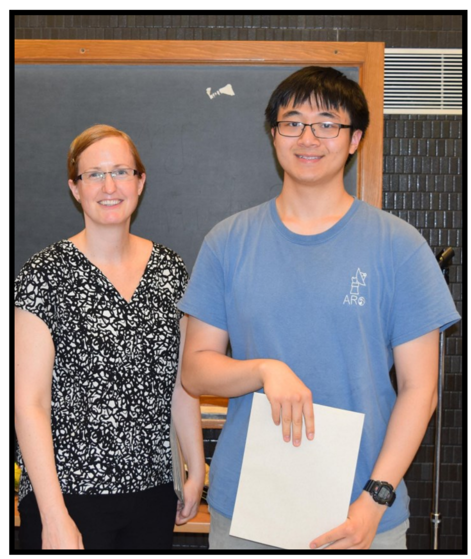
I want to pursue graduate studies and see where research takes me.

Where do you see yourself in 10 years?

Doing the same kind of thing as right now, except I'll know a lot more.

Tell me something interesting about yourself.

One time I went to Romania and was chased down a street by wild dogs.



Chris Ni receiving his CAP University Prize Exam Award from Sabine Stanley in June 2016

2016-2017 Awards

The Van Kranendonk Teaching Award

The Van Kranendonk Award is given every year at the beginning of September to four graduate students who have held Teaching Assistantships during the current academic year.
Nominations come from undergraduate students enrolled in courses in which the TAs are working.

This year the recipients are:

Madeleine Bonsma ***Robert Les*** ***Zaheen Sadiq*** ***Hudson Pimenta***

Luste Prize Recipients

These prizes were set up via a generous donation by the late Professor George Luste to recognize and support undergraduate physics students of merit. George always believed in financially supporting higher education.

George Luste Prize in 1st Year Physics:
Joshua De Sousa Casal, Jennifer Chen, Fan Shen and Stefan Divic

George Luste Canadian Association of Physicists University Prize Exam Award:
Chris Ni, Oguzhan Can and Ramanjit Sohal

George Luste Prize in Biological Physics:
Danielle Carole Denisko

Brian Wayne Statt - George Luste Prize in Experimental Physics:
Megan Tan, Dominique Trischuk, Piotr Bartniki and Flora Hay

Professor George Luste

You can donate to the Luste In Program Scholarship online: donate.utoronto.ca/physics

How One Student is Making Waves in the Fabric of Space-Time

Heather Fong is a Physics PhD candidate who is doing research on gravitational waves. She is also the recipient of the EF Burton Fellowship in Physics

In Grade 6, my teacher gave us an astronomy assignment and I started reading about stars and galaxies, what they're made of, the legends of the constellations, learning new vocabulary like supernova, which is an explosion of a dying star.

In high school, I devoured every astronomy documentary I could find, including ones narrated by Morgan Freeman.

I took my first course in astrophysics in my second year of undergraduate studies at the University of British Columbia, and I fell in love with the images from the Hubble Space Telescope.

In my third year of undergrad, I attended the Canadian Astronomical Society Conference and saw a presentation on LIGO, the Laser Interferometer Gravitational-Wave Observatory, and I learned about gravitational waves for the first time. It was the coolest thing I'd ever heard. Ripples in the fabric of space-time. It gave me goosebumps.

U of T is the only university in Canada doing research on LIGO so I knew I had to come here for my graduate work.

I joined the LIGO team in August 2015. We expected to spend months, maybe years, refining our work so that we might eventually detect gravitational waves. We made our first detection within the first week.

Gravitational wave detection came at around 6am Eastern Standard Time on September 14, 2015. It was such a powerful signal we didn't think it could be real. We spent a lot of time analyzing and examining it, thinking it could've been a false signal put into the data as a test.

But it really was the collision between two black holes.

It was the first-ever direct observation of gravitational waves, something Einstein only theorized about in 1916. There we were, 99 years later and we have our first direct evidence that black holes actually exist.

I compare it to when Galileo looked through a telescope and saw the moons of Jupiter. For the next 400 years, we learned to see farther and clearer with electromagnetic light. LIGO is a different kind of observation, one not based on light but on gravitational waves, and it opens up a whole new way of exploring the universe.

My role was to calculate estimates of how many binary black holes can we expect to observe.

I was just in Japan for the summer doing research at the University of Tokyo with Professor Kipp Cannon. He was the person who gave the presentation at the conference about LIGO that first excited me about gravitational waves.

Help support our students who are working on the frontier of scientific discovery: uoft.me/givephysics

3rd Annual Emeritus Reunion Lunch!

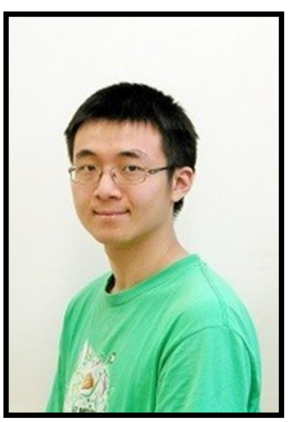
The 3rd Annual Emeritus Reunion Lunch was held on Tuesday, May 17, 2016 at the Faculty Club. Our Emeritus Faculty had the opportunity to catch up, have some lunch and hear about what current faculty are up to.

Back row from left: Reshmi Desai, Ken Norwich, David Rowe, Amar Vutha, Sabine Stanely, Nigel Edwards, Andee Goldman, Richard Bailey, Anthony Key, Aephraim Steinberg, John Perz, Malcom Graham, Ron Farquhar, Siddartha Goyal and Stephen Julian
Front row from left: Kappu Desai, Patricia Ann Moffat, John Moffat, Fraser Code, Ted Litherland, Henry van Driel and Gordon West

Canadian Association of Physicists University Prize Exam Results

U of T takes 3 of the top 10 Spots in Canada!

Physics Students at the University of Toronto proved once again that they belong to one of the top educational facilities in Canada by taking 3 of the top 10 spots in the CAP University Prize Exam.



Chris Ni – 2nd place

Oguzhan Can – 7th place

Ramanjit Sohal – 10th place

The CAP University Prize Exam is a national competition open to students across the country who are enrolled in an undergraduate program at the time of the exam.

CONGRATULATIONS TO THE TEAM AND THANKS TO THE COACH PROFESSOR ROBIN MARJORIBANKS!

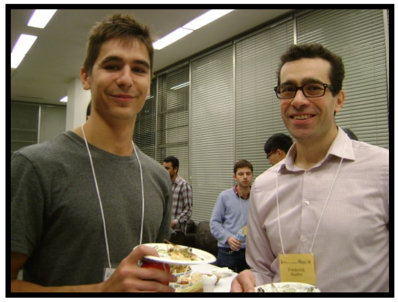
Sponsored by:

physCAP Recap - Mentorship Program

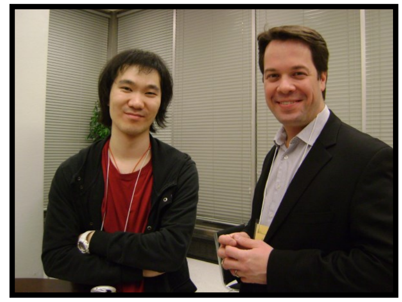
Here are some photos from the 2015-2016 Mentorship Program. This past year we had 49 student mentees and 47 mentors. Our mentors consisted of alumni, faculty and graduate students who met with their mentees once a month. Mentees were given advice on careers, grad school and more. Mentors have told us it's a good feeling to give back and that they enjoy being helpful to students. Thank you to our mentors!

Mentorship Program Mid Term Party

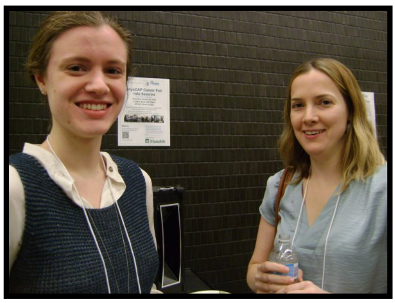
Mentee Alex Cabaj and mentor Henry van Driel



Mentee Ben Barocsi and mentor Frederick Keuhn



Mentee Chengyun Li and mentor Anthony Moots



Mentee Dominique Trischuk and mentor Jenna

Mentees Mike Bertrand-Pickfield and Ben

Mentees Mike Park and Yuan Yao and

Mentorship Program Closing Party

We are looking for alum to be:

Mentors in the Mentorship Program

Speakers at the Career Fair

Hosts in the Job Shadowing Program

Interested? Contact us by:

email mentorship@physics.utoronto.ca or visit: uoft.me/physcap

Spring Reunion 2016

Spring Reunion took place on Saturday, May 28, 2016. The Department participated by hosting two events: Kid's Passport U of T for the little ones and Tours, Talks, Wine and Cheese for the adults.

Kid's Passport U of T - The first ever Spring Reunion children's event was held this year across various departments at U of T. At Physics, Jason Harlow and four undergraduate volunteers hosted a drop in session for the children and their parents. Our guests were amazed by pattern formation, chaos theory, kinematics, superconductivity and more!

Tours, Talks, Wine and Cheese - This was the third year for this event at Physics. This year, Andrew Meyertholen filled alumni in on the current physics curriculum for undergraduates, and graduate student Heather Fong gave an amazing talk on black holes. Tours consisted of the undergraduate teaching facilities, physics learning and research services and labs with superconducting materials and ultra-bright electrons.

At Spring Reunion 2017, the Department will be celebrating the 50th anniversary of McLennan Physical Labs. Stay tuned for more information and we hope you can join us.

For more information on Spring Reunion at U of T visit: https://springreunion.utoronto.ca/

Science Unlimited Summer Camp
@utoronto

Science Unlimited Summer Camp was held August 8-12, 2016 and it was sold out for the 2nd year in row. 50 high school students participated in workshops from the departments of Physics, Astronomy and Astrophysics, Chemistry, Earth Sciences, Math, Computer Science and the School of the Environment. A total 69 volunteers from these departments made the 2016 camp a huge success! Please see below for some pictures

For more information visit: https://sites.physics.utoronto.ca/summercamp

A new addition to the Student Machine Shop

In May 2016, the student machine shop took delivery of a brand new milling machine, eliminating a teaching bottleneck. Before its arrival, students had to wait their turn to use the older mill. Now, with an additional mill, the wait times are substantially reduced.

Paul Woitalla, the student shop supervisor, also took the opportunity to reorganize the shop to make it more organized, safer and easier to use.

A milling machine uses a rotary cutter to remove material from a work piece. The spinning cutter is held stationary while the table holding the work piece moves in two directions to feed the work piece into the cutter.

A mill is commonly used to square up a block of metal (making all surfaces perpendicular) or to carve out the material in a pre-determined design.

The Student workshop teaches graduate students basic machining skills giving them knowledge and skills that will be a valuable resource to them during their time in Physics and in their careers. The student shop and Paul's expertise are also available to those who have taken the training outside of class hours to help make their projects a success.

Many physics departments are closing their machine shops due to budgetary pressures, but we are determined to maintain a well-equipped student workshop, in addition to our main workshop. We believe it is important for students in experimental physics to be able to design equipment. The addition of custom built equipment to an experiment can give a decisive advantage over off-the-shelf apparatus.

Paul Woitalla

Undergraduate Research Fair

On Monday, April 11, 2016 the Undergraduate Office and PASU hosted the Undergraduate Research Fair in the Physics Lounge. This fair was an opportunity for our undergraduate students to showcase their work.

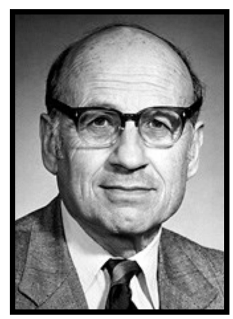
Associate Chair of Undergraduate Studies Sabine Stanley said her favourite part of the Research Fair was seeing all of the excellent research work done by our students. She also said they did a great job making their posters.

Please see below for some pictures from the afternoon.

In Memory

Walter Kohn 4T5
March 9, 1923 - April 19, 2016

Walter Kohn was a theoretical physicist who graduated from the Math and Physics program at U of T in 1945. He become one of the world's most prominent scientists. His accomplishments include: being the founding director of Kavli Institute for Theoretical Physics (then the Institute of Theoretical Physics) and winning the Nobel Prize in Chemistry in 1998.



Walter Kohn
(photo credit: Wikipedia)

Employee Anniversary

In this newsletter we pay tribute to Robert Morley who has been a member of the Physics Electronics Resource Center (PERC) for fifteen years. Robert is a graduate of the Devry Institute of Technology with a diploma in Electronics Engineering and a Bachelor of Science degree. He has continued to develop and strengthen his skills, particularly in digital and programmable logic and circuit board design. Robert enjoys the new challenges that each project brings and seeing how his work contributes to the researcher's success.

Robert Morley

Electronics is constantly evolving. In his fifteen years, Robert has seen electronic devices becoming smaller and using less power while becoming increasingly complex. Robert is continually challenged to stay abreast of new developments and technologies and how they can be applied to physics research. A key part of his job is working closely with students, both during the design of experimental apparatus and in teaching electronic and soldering skills in the workshops that PERC offers.

In his spare time Robert likes to camp, fly Quadcopters and enjoys spending time with his family.

Along with the Mechanical workshop and Graphics, PERC is a member of the Technical Services group. The Physics Electronics Resource Center (PERC) designs and builds leading edge electronic apparatus to support teaching and research in Physics and the University of Toronto. In addition PERC teaches basic electronic skills to graduate students and provides LabVIEW support (LabVIEW is a programming language).

Congratulations to our June 2016 PhD Graduates

Back row from left: Marat Mufteev, Shreyas Potnis, Grzegorz Dmochowski, Matin Hallaji, Vijay Venkataraman
Front row from left: Matthew Russo, Aaron Sutton, Jing Zou

PhD degrees awarded in June 2016

KINGHORN TAENZER, J. "Study of the Higgs boson produced in association with a weak boson and decaying to WW* with a same sign dilepton and jets final state in √s=8TeV pp collisions with ATLAS detector at the LHC"

VENKATARAMAN, V.S. "Perspectives from ab-initio and tight-binding: Applications to transition compounds and superlattices"

TIAN, Y. "Exploring Many Body Interactions with Raman Spectroscopy"

ZOU, J. "Picosecond Infrared Lasers (PIRL): Applications in Biodiagnostics and Towards Quantitative Mass Spectrometry"

RUSSO, M. "Magnetized Astrophysical Flows"

SUTTON, A.B. "Electronic States of Heavy Fermion Materials"

POTNIS, S. "Tunneling Dynamics of a Bose-Einstein Condensate"

OLSEN, K.S. "Temperature and Pressure Retrievals and Mitigation of the Impact of Dust for a High-Resolution Fourier Transform Spectrometer Mission to Mars"

HALLAJI, M. "Weak Value Amplification of a Post-Selected Single Photon"

DMOCHOWSKI, G.M. "The End of N-Scheme"

Physics Flashback

British Association for the Advancement of Science Annual Meeting 1924

In August 2016, Professor Stephen Morris received the photo above from Professor Jean Barrette from the Physics Department at McGill University.

The photo was taken in front of the old physics building during the annual British Association for the Advancement of Science meeting.

The annual British Association for the Advancement of Science meeting was held in August 1924 in Toronto at the Department of Physics. The photo shows the participants for “section A” (Physics and Math). The meeting was an opportunity for the mingling of British, Canadian, American and European scientists, giving them “an unique occasion for acquainting themselves with the manifold scientific interests of the Dominion”, according to the program.

The conference was chaired by J.C. McLennan himself and featured public talks by Arthur Stanley Eddington, D’Arcy Wentworth Thompson, Sir William Bragg and one R. Robertson, who gave a presentation with the title “Explosives (with experiments)”.

Excursions took members to places to the goldmines of Kirkland Lake, the mines and mills of Sudbury and the pulp and paper plants of Iroquois Falls in Ontario and more across the country.

Can you identify the following well-known people in the photo?

Earnest Rutherford
Sir William Bragg
John C. Fields (mathematician)
John C. McLennan

W. Lash Miller (chemist)
E.F. Burton
Lewis Fry Richardson
Arthur Holly Compton

C. V. Raman
E. A. Milne (astronomy)
H. H. Plaskett (astronomy)
R. W. Wood (optics)

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Physics Funny

Q: Why does hamburger have lower energy than steak?
A: Because it's in the ground state.