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Graduating Class of 2006

On Wednesday, April 5, 2006, the graduates organized a special celebration in the Great Hall of the University Club where family, friends, professors and staff all joined in the celebration of their graduation.

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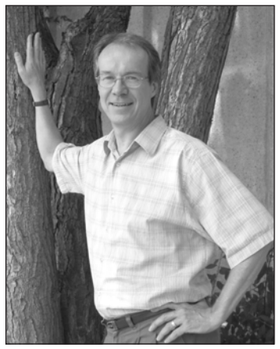
Department of
Physics and Astronomy

SUMMER 2006

Message from the Chair



David Venus

Looking at the picture to the left, you can see that the department of Physics and Astronomy has a new Chair. Let me introduce myself: My name is David Venus, and my research group studies magnetism in films a few atoms thick. Because I was first appointed to the department in 1988, I expect that I already know many of you, and you know me. I hope to hear from you over the next few years.

On behalf of the department, I would like to begin by thanking John Berlinsky, the past Chair, for his leadership and hard work during the last five years. During this time, nine new faculty members have been hired – bringing with them fresh ideas for undergraduate programs and teaching, and fascinating research directions for graduate students to participate in. Some of these recent appointments are profiled in this edition of the newsletter.

The newsletter also describes exciting developments in the undergraduate program. Our new Outreach Co-ordinator Caroline Burgess is working with area highschool students and physics teachers to make our department more accessible through class visits, university events such as the Science and Engineering Olympics, and discussions with teachers about the Ontario highschool mathematics and science curricula. If you are involved in teaching physics in a highschool, she would love to hear from you at burgcar@mcmaster.ca. She is also helping undergraduate students in the large common Science I class to connect with our department and Honours program.

This issue includes a description of the new "Big Questions" course designed by Bill Harris and cross-listed in the Origins Specialization stream. News too recent for the press deadline is a Petro-Canada 2005 Young Innovator Award for Alison Sills to develop research oriented undergraduate teaching. Also, the undergraduate students themselves continue to make waves – spear-heading a new university wide Astronomy Club, and once again taking over the Department in the summer with about 30 summer research positions. Finally, I am very pleased to announce that the initial stage of the Jim Waddington Prize in Physics or Astronomy has been endowed at a level of an annual $500 award. The first recipient is Emma Mazurek. Through your continued generous contributions, we hope to be able to offer more than one prize per year.

I hope that you enjoy our fourth newsletter. If this copy found you in a round about fashion, please get in touch so that we can send you the next one directly.

With best wishes,
David Venus
Professor and Chair

Alumni - Where are they now?

Chris Taylor (PDF 1997) is an assistant professor at California State University, Sacramento.

Jason Fiege (PDF 2000) has accepted a tenure track assistant professor at the University of Manitoba.

In this issue.....

Faculty Profiles

Takashi Imai

I was born and raised in Tokyo, one of the most crowded, expensive, and competitive cities in the world. My first experience abroad came at the end of my third year at the University of Tokyo; I back-packed in Europe for one month. I liked the experience. Then next year, I opted to skip the commencement, and back-packed in Hawaii and New Zealand. It was two weeks after the new term had started when I reluctantly showed up in the graduate school of the University of Tokyo. By that time, my fate had been sealed, I realized that the world is large and that there is plenty of space elsewhere. Why do I have to confine myself to a small island? Moreover, I was an airplane junky from my childhood, and flying was so exciting. Thus the endless but exciting cycles of "take data, publish a paper, then travel abroad to present the results" started. After graduate school, I left Japan in 1991 for the U.S. to do a postdoc, and never went back. 14 years have passed since I moved to North America, and I am still repeating the same cycle faithfully, starting with "take data...". The only major change in this cycle is, after eating too much airline food, I now feel sick just smelling "the" lasagna (which has a very distinctive smell that I can sense from 2 miles away). I moved my lab from the U.S. to Canada three years ago, and flying primarily with Air Canada has made my life somewhat easier (they don't serve "the" lasagna). Nonetheless, I am still afraid of the smell of airline foods. But I like quantum magnetism, superconductivity, and strongly correlated electrons. I can't expect the end of the cycle any time soon.

James Wadsley

I was born in Tasmania and grew up in Melbourne, Australia. I completed my undergraduate at Monash University in Applied Mathematics. The department there is broad with interests in meteorology, general relativity, magnetohydrodynamics (Paul Cally) and stellar astrophysics (John Lattanzio) among many other things. I worked with Joe Monaghan, the leading advocate of Smoothed Particle Hydrodynamics (SPH) as a numerical method to tackle problems in everything from astrophysics to tsunamis. My interest in astrophysics piqued, I successfully applied for a Commonwealth scholarship to do graduate studies in Toronto. There is a strong link between the Canadian Institute for Theoretical Astrophysics (CITA) and Monash. I completed my Ph.D. in 1998 with Dick Bond of CITA in the Astronomy Department at the University of Toronto on "Gasdynamical Simulations of the Lyman Alpha Forest". Australian universities don't teach much undergraduate astronomy. When I arrived I didn't know what a magnitude was and I still don't comprehend why astronomy continues to use them. I met my wife Tara in Toronto and my kids have as many as four passports each. I like Canada from many perspectives and I am happy to have been living here (or nearby) since that time.

For my postdoc I went to the University of Washington (UW) in Seattle. Seattle is a great place and the university is in a beautiful location. I was part of the N-body shop formerly run by George Lake and now headed by Tom Quinn. I was rapidly indoctrinated into the ways of supercomputing and parallel programming, largely by Tom and Joachim Stadel. I implemented SPH gas dynamics in the existing gravity code to create "Gasoline". I also worked with Craig Hogan, Fabio Governato (Galaxy Formation) and Lucio Mayer (Planet Formation).

In 2000 I returned to Canada to take a postdoc at McMaster with Hugh Couchman and Ralph Pudritz. I was impressed by McMaster's cohesion and research strength and I enthusiastically took part in supervising students. My computing interests led me to take a Senior Research Associate Position with SHARCNET with consulting responsibilities. I soon realized that I needed the independence and stronger research focus of a fully academic position and successfully applied for an Assistant Professor position in Physics and Astronomy in 2003.

Brian King

The rain is falling as I sit down to write this bio sketch - what my Irish parents would call a "soft day". The fact that it cheers, rather than depresses, me is no doubt due to my West Coast Heritage. I was born just outside Vancouver, BC in the town of New Westminister and grew up in nearby Surrey. Amongst the many gifts my parents shared with me were a love of a reading and learning from my mother and a questioning eye for the world around me from my photographer dad. Their low-pressure support for whatever I wished to try gave me a wonderful start on my life.

I always loved the idea of "inventors," and of discovering the mysteries of the world around me. I actually remember my first

dramatically expanded (or inflated) for a prolonged period of time, but it has been a long-standing problem to find a microscopic theory that can produce such inflation. My collaborators and I recently found that string theory may actually do so in a calculable way, with the inflation being driven by the relative motion of the branes with which the early universe was populated.

More recently I have also been pursuing another direction: trying to understand the nature of the universe's Dark Energy density. Recent observations indicate that ordinary atoms make up at most around 5% of the universe's energy density, with the rest consisting of two kinds of unknown forms of matter: Dark Matter (25%) and Dark Energy (70%). Although the Dark Energy is most easily understood as being the gravitational response of the energy of the vacuum, there has been a long-standing puzzle (called the Cosmological Constant problem) to do with understanding why this gravitational response should be as small as is observed.

The puzzle is that quantum mechanics leads us to expect there should be quite a bit of energy tied up in the vacuum, much more than is inferred from its observed gravitational response. The question is why the vacuum should gravitate so much more weakly than would be expected from calculations of its energy constant. My collaborators and I have argued that D-branes could also have implications here. It turns out that the gravitational response could be much smaller than normally expected if strings are as large as 10-19 m long, and if there should be two extra dimensions which are as large as 10-6 m or so. If our picture is right then we should know very soon: it predicts observable signals for the LHC, as well as deviations in Newton's inverse-square law of gravity for distances smaller than 10-6 m.

The first annual Jim Waddington Prize in Physics & Astronomy was awarded to Emma Mazurek by Jim Waddington at a gathering of undergraduates and Professors in the Department. Emma, who achieved the highest standing in Physics 1BA3, is currently in Level 2, Honours Physics. See back page for more information.

Big Questions:

Science 2B03 "The Big Questions" has now started its third year of operation, and for the first time this year is cross-listed as Origins 2B03, now fully spliced into the new Origins Specialization stream. After seeing 180 students in our first year, and 220 the second year, our expectations were high. Would the appeal of this course continue to rise? Even our wildest dreams were exceeded when we found that enrolment this fall was reaching 400 and we had to call the registrar's office in desperation to put on an emergency cap. We are now filling the 3rd largest lecture theater on campus (CNH-104) and getting this huge class going, with a team of 4 lecturers and 13 TAs, has been quite a ride.

Our goal is to talk about selected frontier questions (cosmology, space and time, the origin of the elements, and the evolution of life on Earth) in a way that will reach students from anywhere and any faculty on campus. This is a challenge, but it's been rewarding and exciting in a way that no other undergrad course has been. Students rely a lot on our small-group discussions (the main job of the TAs) in which they can talk freely about followup questions, and trade perspectives with other kinds of students they would normally never work with. Hearing and seeing their outlooks, and realizing that a lot of the "big questions" they had about the universe are actually getting answered, is a continual delight. We've seen sketches of what a photon looks like from the viewpoint of a humanities student. We've had students suggest that if the speed of light were small (a few meters per second) then different parts of your body would suffer differential timedilation as you walk. Every week there is something new!

Alumni - Where are they now?

Roby Austin (Ph.D. 2004) has been granted a NSERC University Faculty Award at Saint Mary's University where she will be an assistant professor in the Department of Astronomy and Physics.

Andrew Layden (PDF 1996) is an assistant professor in the Department of Physics and Astronomy at Bowling Green State University in Ohio.

students. We tell prospective students that a degree in Physics will give them a powerful set of problem-solving skills in demand throughout the economy and that, because they are not tied to any one sector, Physicists can manage their careers to provide the right balance (for them) among job satisfaction, salary and a flexible work environment. The annual Physics Career Night at which four or five Physics alumni are invited to speak to our students provides concrete examples of Physicists enjoying a variety of satisfying careers. However, we would like to hear from many more of our alumni about their career paths. Please write to us and let us know what you have been doing with your degree in Physics!

Caroline Burgess (burgcar@mcmaster.ca)

The Story So Far in Particle Physics

by Cliff Burgess

In order to properly describe my own research program I should set the context by describing the present state of my field, which is High-Energy Physics, and more recently its interface with astrophysics and cosmology. The frontier of physics at the very smallest distance scales broadly breaks up into two categories (which described in more detail below).

At 'large' distances -those larger than 10-19 meters - there is an extremely successful theory, imaginatively called the Standard Model. Until a few years ago this theory provided an extremely successful description all experiments that have ever been performed. All but one of the elementary particles predicted by the Standard Model have since been discovered. The one missing piece is the Higgs boson, whose discovery may (or may not) await the completion in 2007 of the construction of the Large Hadron Collider (LHC) in Geneva.

Despite its spectacular success, it has long been known that the Standard Model must fail at shorter distances than 10-19 m, since consistency issues within the theory point to its downfall in this regime. This failure is just beyond the reach of current experiments, but knowledge of its possibility has also informed the design of the LHC, which hopes to experimentally probe scales short enough to see how this failure takes place. One of the categories of research alluded to earlier devotes itself to testing the Standard Model, and trying to figure out in which precise ways it might fail at the LHC. This is often called the 'bottom up' approach to particle physics.

The second category to research also seeks to know what replaces the Standard Model at short distances, but takes its clues from gravity rather than from more traditional particle physics. Gravity is by far the most difficult kind of physics to consistently describe at distances short enough that quantum effects are important, and until the advent of String Theory in the early 1980's absolutely no consistent theory of short-distance quantum gravity was known. The logic of this line of research is to use String Theory to try to understand what might be expected once experiments begin to probe beyond the Standard Model's limits of validity.

String theory has proven to be extremely rich, and has provided amazing connections between hitherto unrelated areas of theoretical physics. Consistency requirements also guide the study of string theory, and these have largely played the role usually taken by experiments in guiding theorists so they can make progress in understanding the theory. Among the discoveries to which string theorists have been led since the 1980's is the discovery in the mid-1990's of D-branes, which are soliton-like domain walls which co-exist with strings within the theory.

This discovery revealed an enormous class of underlying symmetries in the theory that linked all of the previously-known string theories into one unifying framework. String theorists have used these symmetries to learn very surprising things about the nature of space and time at very short distances, and more will certainly be learned.

My Own Research Program

My own research has concentrated on studying the implications that String Theory has for longer-distance physics. In particular, I'm interested in exploring the implications that the potential existence of D-branes might have for the consistency issues which make us believe that the Standard Model is not Nature's last word.

The presence of D-branes also turns out to change dramatically the picture of what might be expected from String Theory over the distances to which we will have access once the LHC turns on. It happens that the particles which look like those we have seen in experiments often turn out to be trapped on these branes rather than being free to wander throughout all of spacetime. This possibility had not been taken seriously before and fundamentally changes the kinds of things we should expect to see at experimentally accessible scales.

Right now cosmology provides perhaps the best point of contact between string theory and observations, since the present measurements can probe the properties of the universe at extremely early times, where string theory predicts it has ramatically different properties than were previously expected. Most recently my work has been to recognize how string theory and cosmology can help to solve each other's problems at these early times.

One way I've tried to do so is through the search to find whether string theory can be consistent with inflation. Cosmological

exposure to a description of the Standard Model (much simplified, of course!) - the fact that everything in the universe could be explained in terms of just a handful of particles and forces seemed amazingly beautiful. That may have sealed my fate - but still, when it came time to enroll at Simon Fraser University, I was torn between anthropology, acting, sculpture, and physics. I loved all these things, but in the end decided to try my hand at physics. Still inspired by that Standard Model book, I thought I wanted to become a particle theorist! However, co-op job placements convinced me that I loved tinkering too much to throw it away entirely for a pad of paper, and I decided to become an experimentalist. As I didn't want to throw away the pad, either, I settled on matter-wave optics and quantum mechanics as my field of further study.

After taking a year off (working in a physics lab!), I started grad school at the University of Colorado at Boulder. A chance remark by my quantum prof sent me down the street to the National Institute of Standards and Technology (NIST) and David Wineland's laser cooling/ion trapping group. I signed on with Dave and his talented and supportive cast of characters, and my fate was sealed. Around that time, Peter Zoller and Ignacio Cirac realized that one might be able to build a "quantum computer" with trapped ions, and our group put their idea into practice. So I was lucky enough to get in almost on the ground floor of what has become the new field of Quantum Information!

After obtaining my PhD in 1999 (and enjoying a lot of good hiking, mountain biking, camping, and micro-brewed beer along the way), I took a post-doctoral position at NIST's other campus outside of Washington, DC. Working in the group of Bill Phillips (who had won a Nobel prize for furthering the techniques of laser cooling), myself and another post-doc built up an apparatus to create a Bose-Einstein Condensate for use in ... quantum computing!

I arrived at McMaster in January of 2002, and have been learning the ropes ever since. I'm putting together my own laser-cooled trapped ion apparatus to explore the ideas of quantum information and try to better understand some of the outstanding questions of quantum mechanics. It's been hard work, but it's wonderful to be doing that hard work amongst such talented and supportive colleagues! In the meantime, I've grown to enjoy Hamilton quite a lot - it's a town with real character, nestled in what I believe to be one of the prettiest parts of Southern Ontario.

Alumni - Where are they now?

Muoi Tran, (Ph.D. 2004) has accepted a postdoc position at NRC's Institute for Biodiagnostics in Winnipeg.

Cliff Burgess

I was born in Portage la Prairie Manitoba in a nomadic family which moved from one airfield to another following my father's career as a jet pilot. Being raised in a military environment, together with the usual prospect of living the life of a beer commercial (money, women and cars), inexorably brought me to science as a career.

As a high-school student I was attracted by the idea that the same forces which cause your hair to stand on end electro-statically also hold atoms together. At the time I thought this was chemistry and so I initially wanted to be a chemist before learning that what really interested me was physics. In 1976 I enrolled in Co-op Physics at the University of Waterloo and fell in love with the subject (and with my wife Caroline). I spent three co-op terms working at the Chalk River Nuclear Laboratories and one term in the Polish Academy of Sciences in Warsaw. In 1980 I began my PhD at the University of Texas in Austin under Steven Weinberg's supervision and spent the next several years learning the trade of theoretical high-energy particle physics (which mostly involved acquiring a taste for coffee). Our eldest son, Andrew, was born the summer after I graduated.

The modern incarnation of string theory had burst on the scene in my last year of graduate school, and I spent my post-doctoral years at the Institute for Advanced Study in Princeton learning the ropes (so to speak). In 1987, we moved to Montreal where I started as an assistant professor at McGill. That year I taught my first course, began supervising my first graduate student, we bought our first house and our twins, Matthew and Ian, were born. It was a hectic but exciting time. Our youngest son, Michael, followed two years later completing our family. We remained dyed-in-the-wool (pure laine) Montrealers until the fall of 2004 when the oldest three boys moved off to University and the rest of us moved to Hamilton.

My scientific interests lie somewhere between string theory on one side and particle physics on the other, with the occasional excursion into other areas. I am presently jointly appointed to the Department of Physics and Astronomy at McMaster and the Perimeter Institute in Waterloo and am enjoying the mix of the University and Institute environments.

Graduate Profile

Greg MacDougall

A native Vancouverite, I was first drawn into the world of physics during my undergraduate education at Simon Fraser University. Upon receiving my degree, my fiancé and I jumped in our car and drove across Canada so I could do my graduate studies at McMaster. I am currently a PhD student with Dr. Graeme Luke, using a technique called muon spin rotation (FSR) to study the magnetic properties of new and interesting materials, mostly exotic superconductors. In the last year, I have received a NSERC Canada Graduate Scholarship and had my work presented at the March Meeting of the American Physical Society, the summer meeting of the Canadian Institute of Advanced Research and the 10th International Conference on FSR. But life at Mac is more than just world-class research. To me, one of the most appealing aspects of this department is the opportunity to be part of such a dynamic and social group of individuals, and I consider myself lucky to be here.

Undergraduate Profile

Sarah Dyck

My name is Sarah Dyck and I am in fourth year Astrophysics. I chose physics because I enjoy math and logic problems, but mathematics alone left much to be desired - and it sounded like a good idea at the time. Over the last few years I have become quite involved in the department. I worked with Dr Brian King in his Quantum Computing laboratory for two consecutive summers and did a poster presentation at the CUPC this year on helical resonators. I am also involved with the Physics Society, I am currently VP Social. On top of all of this, I have also helped promote physics and the department at such events as May @ Mac and the Science Olympics.

Outreach Coordinator

Caroline Burgess

I was born in Montreal, one of six children. My love of math probably came from my grandfather who played endless games of cards with his grandchildren. These usually involved some sort of counting - chips, tricks, or trumps - it was important to keep track! My love of teaching came from my mother who in her "spare time" volunteered for countless hours in schools.

I did my undergraduate degree in Mechanical Engineering at the University of Waterloo. My coop jobs ranged from the bizarre and smelly (tour guide in a garbage recycling plant) to the very interesting (failure analysis of aircraft parts and refrigeration systems for magnetic levitation trains). Between graduation and grad school, I took a job teaching math in a private school and decided this was my niche. I switched programs and completed my Masters in Mathematics Education at the University of Texas at Austin.

Meanwhile I had married Cliff, a physicist, and his career took us to Austin, then Princeton and finally back to Montreal. We had four children, Andrew, Matthew, Ian and Michael (in four years!), and I continued to teach math and science and to volunteer in schools when I could find the time. I taught students in pre-kindergarten, college and everything in between. Each level presented its own set of challenges and rewards.

After seventeen years in Montreal, three of our sons were applying to universities in Ontario and we decided this was a good time for Cliff to take up an offer from McMaster University and move there ourselves. So here I am, Outreach Coordinator for the Department of Mathematics and Statistics and Physics and Astronomy, and I couldn't be happier. This job allows me to use all of my education and experience. I interact with students and teachers and I work with people in both departments who share my passion for math and science education. We love living in Hamilton and, best of all, our sons are all within an hour's drive!

Alumni - Where are they now?

Guillaume Gervais ((MSc 1997) has accepted a junior faculty position at McGill University.

Special Announcements

Bruce Gaulin, professor physics and astronomy has been elected to Fellowship in the American Physical Society as a recognition by his peers of his outstanding contributions to physics. He is cited "For leadership in the application of scattering techniques to problems in phase transitions and magnetism".

The first annual Jim Waddington Prize in Physics & Astronomy was awarded to **Emma Mazurek** by Jim Waddington at a gathering of undergraduates and Professors in the Department. Emma, who achieved the highest standing in Physics 1BA3, is currently in Level 2, Honours Physics.

William Harris, professor of physics and astronomy and the world's leading expert in the study of globular clusters in galaxies, has been inducted into the Royal Society of Canada. Fellowship in the society is considered one of Canada's most prestigious academic accolades to which scholars and scientists aspire.

Hugh Couchman, professor of physics and astronomy, has been appointed the Scientific Director of SHARCNET (Shared Hierarchical Academic Research Computing Network), a multi-institutional high performance computer network system. Dr. Couchman has been a significant contributor to SHARCNET over the last few years, being one of the original grant writers and founders of the organization. The Shared Hierarchical Academic Research Computing Network (SHARCNET), has received an investment totaling $50 million that will allow the investigation of the structure of matter, through computer simulations, down to the nanometer scale.

A $250,000 science and engineering research prize has been established in honour of the late **Bertram Brockhouse**, winner of the 1994 Nobel Prize in Physics. The award, the Brockhouse Canada Prize for Interdisciplinary Research in Science and Engineering, was conceived as a 25th anniversary project of NSERC to permanently recognize Dr. Brockhouse's contribution to science and to Canada.

Congratulations are in order for our graduate students returning with end-of-meeting prizes from the annual meeting of the Canadian Astronomical Society in Montreal this year. From the national astronomy grad student association, one of the two prizes for best poster presentation by a student went to **Sijjin Shen** and for best oral presentation to **Steve Bickerton**. From the CASCA Board of Directors, the prize for best oral presentation went to **Soko Matsumura** with an honourable mention to **Steve Bickerton**.

All 153 members of the department were congratulated by way of a free lunch at the University Club for the best participation on campus for the Commuter Challenge, a week-long event that takes place across the country to encourage people to find other ways of getting to work other than by driving alone. Lecturer **Ken Sills** and senior physics student **Christian Veenstra** were commended and presented with gifts for their successful organizational work.

Outreach

The goals of our outreach program are to raise the profile of Physics & Astronomy at McMaster University and to recruit more students into our Honours Physics program. Our impression from talking to students, teachers and Guidance Counselors is that most students in high school are reluctant to take Physics for fear that it will lower their averages and that those who do have an aptitude for Math and Physics believe that the prospects for a successful career are better in Engineering. In addition, we know that a majority of students entering Science I at McMaster intend to pursue degrees in the Life or Health Sciences. The fact that at least one first-year Physics course is a requirement in almost all of the Science programs at McMaster, including Biology, has not filtered down to the high schools. While Grade 12 Physics classes have been shrinking, we have seen a sharp increase in the number of students taking our remedial Physics course.

As part of our outreach efforts, the Department hosted a Dialogue, "Building a Community of Physics Teachers", with teachers in the local area on March 8, 2006. There was an exchange of ideas between teachers and faculty about curricular reform, the sharing of resources, and ways in which to raise the profile of Physics in schools and the community at large, including reinforcing the message that Physics is a fundamental science which is a necessary basis for understanding all other sciences. We hope that this will be the first in a regular series of meetings. We are also offering "Physics@Mac" activities during the times when our first year labs are available. Twice a year, in December and April, we invite High School Physics classes to participate in their choice of activities from a list which includes a first-year lab on waves, a tour of research labs, a series of physics demonstrations, and a planetarium show presented by one of our graduate students in Astronomy. We also hope to offer teachers the opportunity to arrange presentations by faculty or graduate students at their schools.

The perception that career prospects in Physics are poor (or at least not as good as those in Engineering) is being addressed on a number of fronts. We are working closely with Science Career Services and Science Co-op to ensure that students in our program make the most of opportunities available to obtain relevant work experience while undergraduates. We also offer summer research opportunities in the Department to many of our