Summer 2014

OAPT Newsletter

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The OAPT was formed to advance the teaching of physics in the secondary schools, colleges, and universities of Ontario. For more information on the OAPT, visit our website at **www.oapt.ca**.

The OAPT newsletter is published four times a year. Back issues and submission guidelines can be found at **www.oapt.ca/newsletter/**.

Ontario Association of Physics Teachers

OAPT Executive

Editor's Introduction

In this issue we report on the happenings at our annual conference, which took place on May 7 – 9 at the University of Toronto.

We are deeply grateful to our conference hosts for this year, the Edward S. Rogers Department of Electrical and Computer Engineering (ECE). The ECE department has been for many years been a generous supporter of the OAPT, both for the conference and for our annual grade 11 physics contest. As our hosts this year, they not only provided hospitality but also several presenters who let us know about some of the latest exciting developments in technology being pioneered at the University of Toronto.

Following a great keynote address by Bonnie Schmidt of Let's Talk Science and movie and TV producer Paul Rapovski, we all got a tour of the ECE department, featuring some of their very impressive students. For those of you who were not fortunate enough to attend the conference, allow me to recommend such a tour the next time it is on offer. It will rejuvenate your faith in education and its potential to equip young people to solve the world's problems.

Speaking of the world's problems, the sessions covered in this issue range from the esoteric mysteries of particle physics and cosmology to the very practical issues of gender equity and career development. What is perhaps open for debate is which one of these ends of a spectrum is the Roots of STEM? Read on...

Table of Contents

Session Reviews

There were many excellent sessions at this year's conference at the University of Toronto. Here is a small sampling. If they look interesting, plan on attending next year's conference in Guelph.

Perimeter Institute: The New Cosmology Resource

Kevin Donkers, Dave Fish & Damian Pope

In this session we got a sneak peek at the new cosmology resource coming in Autumn 2014 from the Perimeter Institute (PI). With so many excellent teacher resources already available from PI this one will hopefully be another winner. This new resource will include activities for junior science as well as senior physics.

Kevin, Dave and Damian began by talking about the recent advances in our understanding of the origins of the universe and the work the PI has been doing on this problem. They explained that the Big Bang led to today's Cosmic Microwave Background (CMB) and a temperature profile across the universe that is not smooth but 'lumpy'. They showed a Minute Physics video that does an excellent job of explaining these observations.

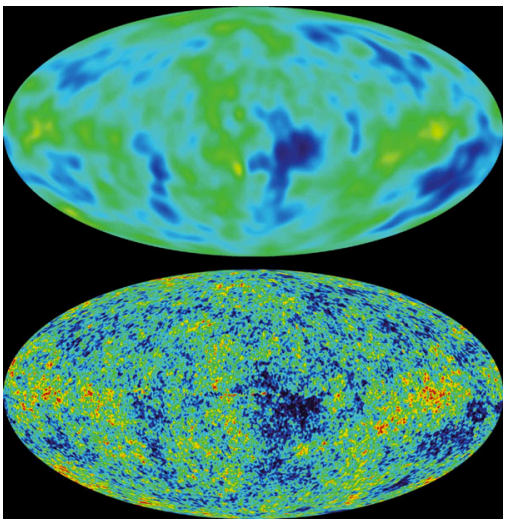

Figure 1: temperature maps of the universe. (Top: the map made using data from the COBE satellite; Bottom: the map made using data from the WMAP satellite)

A Fourier analysis of the frequencies of the CMB has led to the temperature maps of the universe shown in Figure 1. The map in the top half of the image was made using data from the COBE satellite, which was able to resolve temperature fluctuations of about 1:100 000. A more detailed version followed using data from the WMAP satellite. This is shown in the bottom half of Figure 1. Data from the PLANCK satellite is currently being processed and will give us an even clearer picture.

Students can do their own frequency analysis of an electromagnetic signal using downloaded software or LoggerPro. The new PI resource contains activities that show students how to do this, as well as how to perform a power spectrum analysis radiation. There are sure to be many other fun student activities in this latest PI offering. How well they will align with the Ontario Science curriculum? How well will they engage students? We will have to wait and see, but I am definitely eager to find out!

All the handouts for the workshop can be found on the OAPT's resources page: **http://www.oapt.ca/resources/index.html** .

Review by Andrew Moffatt

Links

- Minute Physics: Picture of the Big Bang:
  https://www.youtube.com/watch?v=_mZQ-5-KYHw
- Check here for the new Cosmology Resource in June:
  https://www.perimeterinstitute.ca/outreach/teachers

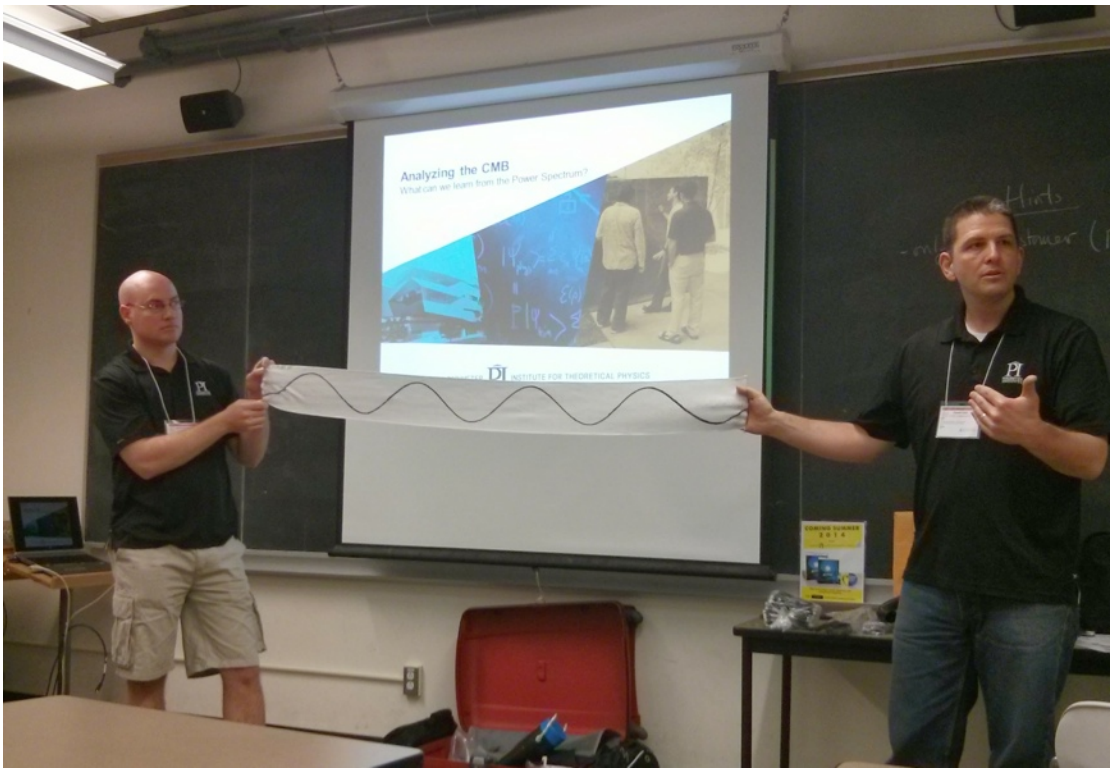

Figure 2: Kevin and Dave demonstrating the lengthening wavelength of the CMB since the Big Bang.

Applying Physics Principles to Build a Career Roadmap

Caroline Burgess and Dr. Ian Burgess

Even with considerable physics skills, it is impossible to accurately predict the future — and yet we can certainly make predictions about what kinds of skills will be useful in the near future. In this session Caroline and Ian Burgess outlined the ways in which a physics education can provide the types of skills and attitudes that students will need as they head into and shape the future.

One pitfall for students outlined by Caroline is a “bin mentality” towards education. This is the assumption that learning is sharply divided into “bins” and that one need only acquire specialized knowledge in the bins that are perceived as important. For example, there is a dangerously career-limiting notion amongst mainstream secondary students that the only people who need

low-level computer skills are those headed for a computer science degree. The Burgesses contend that students should be working towards acquiring transferable skills not restricted to narrow subject definitions. Specialized knowledge declines in value over time, while transferable skills retain their value. Extending the computer example, knowing how to program in C++ might not be a useful skill in 20 years, while the ability to troubleshoot errors in a variety of languages will be.

The Burgesses showed that physics classes provide opportunities to learn several important transferable skills: the ability to translate between words, pictures and equations; making predictions; deduction and derivation from existing sources; and invention. Honing these skills will build students' confidence and make the subject more interesting.

Dovetailing with Chandra Boon`s work (see Stella Kim's review of the "Girls in Science" session in this issue), the Burgesses identified another key to success: the need to attain a "growth" rather than a "fixed" mindset. Some students believe they have a fixed amount of talent in a given subject, and that talent alone can be enough to ensure success. Such students must learn to persevere and put in a full effort, hallmark attitudes of a growth mindset. The growth mindset also leads to a keen sense of curiosity and to the confidence to risk failure, both critical for students to achieve. Caroline encouraged participants to address the 'confidence gap' displayed by female students, who tend to underestimate their ability. She referenced an article in *The Atlantic* outlining the problem. A link is included below.

As teachers we try to prepare our students for the future, but the path forward is somewhat unclear. If we can make sure that our courses emphasize transferable skills rather than specialized knowledge, and if we can encourage perseverance, curiosity, and risk-taking – the signs of a growth mindset – we can be confident that our students will be well prepared.

All the handouts for the workshop can be found on the OAPT's resources page: **http://www.oapt.ca/resources/index.html** .

Review by Greg Macdonald

Links:

- "The Confidence Gap" ,*The Atlantic*, April 2014: **http://www.theatlantic.com/features/archive/2014/04/the-confidence-gap/359815/**
- Physics and astronomy page at McMaster University, lists transferable skills that graduates will have obtained: **http://www.science.mcmaster.ca/scce/students/career-info-by-discipline/114-physics-and-astronomy#ja-content**

Girls in Science

Dawn Britton, Dr. Shohini Ghose & Chandra Boon

Dr. Shohini Ghose

Chandra Boon

Women have been long underrepresented in physics and engineering. In this thought-provoking panel discussion Dawn Britton, Associate Director of Engineering Outreach at the University of Toronto, and Dr. Shohini Ghose, Director of the Centre for Women in Science at Wilfrid Laurier University, provided an overview of the history and emerging state of women in the field from a post-secondary perspective. Chandra Boon, a physics teacher at Branksome Hall in Toronto, described a research-based approach she has been using successfully with her high school physics classes to promoting the engagement, achievement and confidence of young women in physics. Work is now being done to promote the equitable representation of women in science, physics and engineering. As educators we have a role in this process.

There are many identified reasons for the considerable gender gap between men and women in science. Role models and mindset were two reasons discussed in detail during the session. With regard to role models, women are seldom mentioned in our science textbooks despite their significant and numerous contributions to science. Highlighted in this session were stories of female astronomers and astrophysicists from 1900 to 1950 including Williamina Fleming (1857-1911), Henrietta Leavitt (1868-1921), the Harvard Computers, and Cecilia Payne-Gaposchkin (1900-1979). These women's work is represented in our textbooks but not accredited to them. They need to be talked about in our science classes because they are role models for our female students by virtue of having demonstrated perseverance through considerable social challenges.

Turning to the second problem, that of mindset, our understandings of ourselves as learners can dramatically affect our short and long term response to learning something challenging like physics. Dr. Carol Dweck, social psychologist and professor at Stanford University, describes two learning states: a growth mindset and a fixed mindset[1,2]. A student with a fixed mindset believes intelligence and skills are fixed and inborn; consequently, she tends to avoid challenges and gives up easily. A student with a growth mindset believes intelligence and skills can be learned and developed. She is more likely to embrace challenges, persist despite obstacles, see effort as a path towards mastery, learn from criticism and be inspired by others' success. Female students are more deterred by performance to choose a STEM career than men with similar or the same academic performance in science and math.

The good news is that learning states can be taught. This means that the learning states paradigm can be used to support female students. Boon has an approach to applying the theory of mindsets in her secondary teaching practice. Near the beginning of her senior physics course she teaches her students how a fixed mindset runs contrary to our scientific understanding of learning and the brain. She also discusses the physiology of stress. Boon then helps her students develop specific strategies to reduce anxiety and test stress, including positive self-talk. Students in the senior class later act as tutors and mindset mentors to grade eight students preparing to write their first set of exams.

There are concrete steps we can and should take to encourage the participation and achievement of women in science and physics. The interventions we implement now in our classroom can have enormous and long lasting impact on the young women we teach. A spinoff bonus is that these interventions will benefit all the learners in our classroom.

All the handouts for the workshop can be found on the OAPT's resources page: **http://www.oapt.ca/resources/index.html** .

Review by Stella Kim

Links

- Laurier Centre for Women in Science: **http://www.wlu.ca/wins**
- Engineering Outreach at the University of Toronto: **http://www.outreach.engineering.utoronto.ca/**

References

1. Dweck, C. S. (2006). Mindset: the new psychology of success. New York: Random House.
2. Dweck, C. S. (2012). Mindset. London: Robinson.

Engineering Contests and STEM

Roberta Tevlin and Andrew Moffatt

STEM-based learning in schools traditionally addresses science, technology, and mathematics, but overlooks engineering. In this workshop Roberta Tevlin and Andrew Moffatt shared ways they bring opportunities for students to learn engineering to their respective schools. At Danforth Collegiate Roberta Tevlin has for many years been running two 'locally developed' interdisciplinary courses that bring engineering into the curriculum. Andrew Moffatt works with students at The Bishop Strachan School mentoring Vex Robotics teams as an extracurricular activity.

Roberta Tevlin

Andrew Moffat

The 4 C's of 21st Century Skills — critical thinking, collaboration, communication, and creativity — were much in evidence at this workshop. Participants had great opportunities to see that contests serve as a powerful means to engage students in designing and building working structures. The projects showcased in this workshop were static boats and elastic-powered cars. Awesome!

Integrating opportunities to learn engineering into the curriculum or extracurricular program of a school is a very worthwhile goal. Students have an innate desire to build structures that work well to accomplish a task. Doing so in teams, and in ways that require them to communicate their understanding to others, is a great way to engender the 4 C's!

Session highlights

- Math matters in the design of structures;
- STEM-based learning can happen in an extracurricular group such as a robotics team: physics can be combined with math and engineering in many ways using Lego or VEX parts to build structures that perform tasks.
- Helpful discussion took place on how to help students form teams and work effectively in them. Having the right combination of students on a team can ensure that roles and responsibilities are accomplished. A fringe benefit of forming teams well is that students who have positive experiences in building structures will share that excitement with their friends, creating word-of-mouth advertising for the course.
- This workshop highlighted the motivational power of team-based competition. Fun!

Many of the projects on Roberta's website (see link below) are useable at all levels of schooling. The static boats could be made by students in elementary science classes, given proper guidance by the teacher. Similarly, robotics teams and competitions have a place in both elementary and secondary schools, though it was Andrew's opinion that Lego robotics is more appropriate than Vex at the elementary level.

The idea of offering students interdisciplinary courses in grades 11 and 12 makes much sense. A course like this one can win over students who might otherwise have been reluctant to enroll in the grade 12 college physics course.

Considerable discussion took place in the session regarding the place and effectiveness of robotics teams in both elementary schools and high schools. It became clear that the combined cost of robot parts and registration fees for competitions can be a limiting factor. Furthermore, the amount of extracurricular time that students have to devote to a robotics team will determine the depth of learning that can take place.

All the handouts for the workshop can be found on the OAPT's resources page: **http://www.oapt.ca/resources/index.html** .

Review by Will Lammers

Links

- Roberta's engineering projects site: **http://roberta.tevlin.ca/Engineering%20Contests/Engineering%20Contests.htm**
- Vex Robotics site: **http://www.vexrobotics.com/**
- Vex Robotics coordinator for Ontario: Karthik Kanagasabapathy, **karthik@vexrobotics.com**

Particles Smarticles: Using Group Interactive Demonstrations to Model Particle Behaviour

James Ball and Saara Naudts

James Ball, an Ontario pioneer in Physics Education Research (PER), and Saara Naudts of the Peel District School Board brought a very engaging hands-on workshop to demonstrate particle behaviour. The workshop started with a video on the beauty of our universe and a clip[1] from the documentary *Particle Fever* about a handful of physicists involved in the discovery of the latest sub-atomic particle consistent with a Higgs Boson at the LHC in Cern.

The workshop involved three activities that illustrated sub-atomic particle behaviour. The first activity demystified particle accelerators. We all had fun playing with different sized balls out in the hallway. The first collision was between two bowling balls, yielding a high head-on collision rate. The second collision was between two tennis balls, yielding a lower rate. The final collision was between lots of marbles, yielding collisions that were not recordable. This revealed trying to produce head-on collisions between something as small as protons is very challenging.

Photography: Rolly Meisel

The second activity demonstrated the challenge of keeping colliding particles moving in a circular path. A continuous strong magnetic field towards the centre of the circle is used for this. We laid out a circle of radius 1 metre using masking tape on the floor and simulated the magnetic field by

surrounding the circle with people armed with hammers. The ball was rolled into the circle on a tangent and each person hit the ball towards the centre of the circle with a hammer.

James and Saara explained about the multitude of sub-atomic particles and the existence of the Higgs field. They showed a video[2] from Fermilab by Dr. Don Lincoln explaining what the Higgs field is and how particles attain mass due to their interactions in the Higgs field. There was some discussion about top quark having 250 times more mass than the electron despite being the same size.

The third activity started with a handout showing particle interactions and their decay into newer sub-particles. Our group role played the movement of particle interaction and decay, conserving momentum, mass and charge. We then calculated the resultant momentum to show conservation of momentum for each particle observed in the DZero detector at Fermilab.

All the handouts for the workshop can be found on the OAPT's resources page: **http://www.oapt.ca/resources/index.html** .

Review by Mhona Russell

Links:

1. Trailer for the movie 'Particle Fever: **https://www.youtube.com/watch?v=Rikc7foqvRI**
2. Video of Dr. Don Lincoln explaining the Higgs field form the Fermi Lab: **https://www.youtube.com/watch?v=joTKd5j3mzk**

Biomedical Engineering

Prof. Stewart Aitchison, Dr. Willy Wong, Dr. Micah Stickel

Dr. Micah Stickel kicked off the session and introduced Dr. Willy Wong and Stewart Aitchison, professors in the Department of Electrical and Computer Engineering (ECE) at the University of Toronto, who presented a seminar about some exciting research projects going on at the department. The projects include development of a device to enhance hearing, a device to create electrical stimulation to restore motor function, and a cytometer on a microchip to detect infectious diseases.

The Future of Hearing Aids

Conventional hearing aids simply boost the amplitude of sound signal. In noisy environments this can result in noise overload and be very annoying. Stanford University professor Bernard Widrow invented a microphone, worn around the neck, which improves hearing aid technology; however, it is very bulky.

U of T ECE is developing a less bulky solution: glasses with beam focusing using multiple sensors to spatially filter the signal. The looking direction of the user governs which source sound

waves is picked up and amplified. The device introduces delays to the sound signals from sources not being looked at, allowing these signals to be filtered out.

Restoring Motor Function

U of T Biomedical Engineering professor Dr. Milos Popovic is working at the Toronto Rehabilitation Institute on an experimental technology called Functional Electrical Stimulation (FES). The goal is to restore motor function to patients with paralysis or movement disorders such as Parkinson's disease. The treatment involves electrical stimulation of peripheral nerve tissue: electrodes are activated at the instant when the brain is signalling the tissues to perform the particular motor function. One signal goes to the muscles and another goes to the brain. The idea is not to substitute permanently for brain function, but rather to train the brain to reconfigure and stimulate the neurons so that they will restore the motor function. Click to watch a video of FES at work and a few success stories:
https://www.youtube.com/watch?v=-QZDdh7Fbu8&feature=g-crec-u

Quick and Easy HIV Tests

Dr. Aitchison described the 'lab on a chip' for HIV testing being developed by a team led by one of his PhD candidates, James Dou. It is a portable cell analyzer designed for mobile blood tests and has won an award for Canadian Innovation. Conventional diagnostic testing for infectious diseases such as HIV involves the use of bulky blood flow cytometry equipment to measure T-cell markers in the blood. In many developing countries this equipment is neither practical nor affordable. Under Aitchison's supervision, Dou and his team developed a cheap, disposable micro-fabricated integrated chip in which the blood gets drawn up through a film onto the chip. The device and the team have been featured in several major newspapers. The articles can be accessed from this site: **http://www.chipcare.ca/**

The knowledge gained in this seminar may be shared with our students to demonstrate some of the exciting applications and pursuits to which their science studies can lead. It is also a reminder for us to try to keep abreast of new research and technology to engage our students' curiosity and interest.

All the handouts for the workshop can be found on the OAPT's resources page:
http://www.oapt.ca/resources/index.html .

Review by Sandy Evans

Links:

- Dr. Milos Popovic and Functional Electrical Simulation:
  https://www.youtube.com/watch?v=-QZDdh7Fbu8&feature=g-crec-u
- James Dou and the 'lab on a chip': **http://www.chipcare.ca**
- U of T Institute of Biomaterials and Biomedical Engineering: **http://ibbme.utoronto.ca/**

Introducing a Canadian Resource and 21st Century Learning Platform:

AccessSTEM

AccessSTEM is a web-based application designed to help students make connections between classroom theory and real-world applications, including career pathways. AccessSTEM's videos, lesson plans, and performance tasks link literacy and numeracy to science and technology.

AccessSTEM combines a number of different content types that accentuate the educational strategies of STEM education. This is truly a cross-curricular differentiated learning resource.

The **AccessSTEM Performance Tasks** present a specific job or industry and require students to apply their knowledge to a problem that will most likely be new to them.

A few examples of performance tasks specific to physics:

- analysis of problems civil engineers face in designing an airport runway;
- industrial design for prosthetics development;
- exploring issues related to the Doppler effect that a satellite analyst may encounter.

The **AccessSTEM Literacy Tasks** ask students to read, synthesize, and write about a career-based topic.

Each **AccessSTEM** resource allows students to apply concepts in real-world scenarios, increasing student performance and preparing them for 21st century careers.

30-day FREE Access for OAPT Members!

OAPT Members: Visit **http://www.AccessSTEM.com** and enter "OAPT" as both the userid and password for 30 days at no charge.

OAPT Physics Contest Results

The date of the 2015 contest is Wednesday, May 20th.

2014 Top Scores			
Score	Student	School	Prizes Awarded
140	Tongle Fong	The Woodlands School, Mississauga	Biophysics summer internship at York U., U. of Toronto DEEP Award, cash prize from the OAPT
135	Oliver Wang	St. Robert CHS, Thornhill	U. of Toronto DEEP Award, cash prize from the OAPT
130	David Francis	University of Toronto Schools, Toronto	U. of Toronto DEEP Award, cash prize from the OAPT
130	Nicholas Huang	St. Elizabeth CHS, Thornhill	U. of Toronto DEEP Award, cash prize from the OAPT
130	Stephen Liu	Bayview SS, Richmond Hill	U. of Toronto DEEP Award, cash prize from the OAPT
125	Wei Hu	Langstaff SS, Richmond Hill	cash prize from the OAPT
125	Zijian Wei	Unionville HS, Unionville	cash prize from the OAPT
125	Wilson Wu	Pierre Elliot Trudeau HS, Markham	cash prize from the OAPT
122	Yi Cheng	Lakefield College School, Lakefield	cash prize from the OAPT
121	Yizhou Deng	The Woodlands School, Mississauga	cash prize from the OAPT

Schools with the most students participating:

- University of Toronto Schools, Toronto: 95 students
- Victoria Park SS, Toronto: 62 students
- North Park SS, Brampton: 47 students
- Bloor CI, Toronto: 33 students
- A. Y. Jackson SS, Toronto: 28 students
- Don Mills CI, Toronto: 23 students
- Vaughan SS, Vaughan: 22 students
- The Woodlands School, Mississauga: 21 students
- Centre Dufferin DHS, Shelburne: 20 students
- North Toronto CI, Toronto: 18 students
- Vincent Massey SS, Windsor: 18 students

Thanks and appreciation to our volunteers:

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