editorial

Think small … think quantum mechanics!

It is always an interesting time to be a physicist! 20th century physics was fascinating. Physics in the 21st century may prove to be even more exciting.

Almost every month, there is an announcement of some new discovery or confirmation of a grand theory. Life, as a physicist, is far from dull. There is no lack of interesting things to learn or research to undertake. Such new discoveries and theories serve to inspire undergraduates to become physicists, astronomers, biophysicists and engineering physicists.

For instance, physicists at Boston College (BoC) and the Massachusetts Institute of Technology (MIT) recently announced that they have used nanotechnology to achieve a major improvement to thermoelectric efficiency, an improvement that may with time allow the fabrication of tiny alloy nanostructures that can serve either as micro-coolers or power generators. In an era where size and economies of scale have driven technology, the future may be different. It may be left to high efficiency microstructures to best define the 21st century. One quarter of the new wealth generated in the 20th century was a direct result of quantum mechanics. Patrick's adage: *Think small … think quantum mechanics!*

The BoC and MIT groups have achieved a significant increase in the thermoelectric efficiency of bismuth antimony telluride, a semiconductor alloy that has been commonly used in bulk form in commercial devices since the 1950s. Through their design and manufacturing techniques, the BoC and MIT groups may have realized a 40% increase in the alloy's figure of merit, a term scientists use to measure a material's relative performance. What they have done is by breaking the bismuth antimony telluride alloy up and then rebuilding it in a composite of nanostructures, they have found a way to improve an old material by using modern manufacturing technique.

What is really exciting is that while the discovery of the thermoelectric effect was made in 1821 by the Russian-German physicist Thomas Johann Seebeck, some two centuries later physicists still find the challenge of increased efficiency and decreased size interesting enough to push Seebeck's discovery into the 21st century. The Seebeck effect is that when you have a junction with no current flow across it a temperature gradient produces a emf across the junction. The Seebeck effect is usually measured in millivolts and is bench top physics. Related effects include both the Peltier Effect and the Thomson Effect. This new found efficiency may be the one of the most far sweeping and one of the most significant contribution to nanotechnology in recent years. It also raises the question: is the Seebeck/thermoelectric effect taught in our high school and undergraduate physics programs?

Some 20 orders of magnitude in the other direction and looking out into the cosmos, another recent announcement relates to high energy cosmic rays. After nine years of observation at the University of Utah's High-resolution Fly's Eye cosmic ray observatory, physicists have confirmed the Greisen-Dugway-Kuzimin (GZK) cut-off. The GZK cut-off was first proposed in 1966 soon after the discovery of the Cosmic Microwave Background (CMB). The trio of theorists predicted the sharp suppression of cosmic rays at an energy of 6×10^{19} eV due to scattering of these ultrahigh energy cosmic rays off the ultracold 2.7 K photons left over from the Big Bang.

Their prediction was based on the assumption that the proton dominated cosmic ray flux, coming from far outside our galaxy, would interact with the photons in the Cosmic Microwave Background via photopion production. From the temperature of the CMB and the mass and width of the Δ+ resonance, a threshold of 6×10^{19} eV was predicted. This, in turn, meant a strong energy loss mechanism that limits the range of cosmic rays above this threshold to less than ~50 Mpc.

The recently announced University of Utah measurements confirm the GZK cut-off. Perhaps the 2009 Nobel Prize in physics awaits Greisen, Dugway and Kuzimin. Some of the most precise measurements of the Δ particle production rates and resonance widths were made at TRIUMF, Canada's national accelerator laboratory, and were used to refine the GZK cut-off theory.

The January 2008 edition of *CUPJ* has become one of the most influential editions to date, with copies presented to the Rt. Hon. Governor General of Canada by Dr. Jaymie Matthews during his investiture in the Order of Canada in February 2008. The interview of Dr. Matthews in the January 2008 *CUPJ* was read with avid interest by the Rt. Hon. Governor General, as was the article *Radarsat-2: Gem in the SAR satellite constellation.* The Radarsat-2 article has been reviewed by Members of Parliament, past and present members of the Canadian Space Agency and other public figures who are trying to chart a future course for Canada in space. We agree with the recommendation that Canada needs a new and forward-looking Canadian space policy and stand ready to assist in the drafting and undertaking of such a policy.

In this April 2008 edition of *CUPJ*, we have an interview of Dr. Tom Ruth, the retiring head of the TRIUMF/UBC Positron Emission Tomography Group. We also have articles on the biological physics of bacteria, continuous quantum measurements, the Lorentz invariant measure and the Heisenberg uncertainty principle and the second article in the Volkoff series – "George Volkoff and reactor physics in Canada." For the first time, the journal has a contribution from a high school physics student, with an article titled Euler's treat: $\exp(ix) = \cos x + i \sin x$. A number of fine submissions have been carried over to the September issue due to a lack of space in this edition.

For those of you who are interested in Canadian physics history, the second article in the Volkoff series introduces us to "Volkoff's Theory of Errors," as explained by the late Canadian physicist Dr. Philip Wallace:

"'Volkoff's Theory of Errors,' the first rule of which was never to make a single error in a calculation, because a second error might cancel out the first. One was hesitant to rely on this theory unless one had a deep belief in one's luck …"

The journal is looking for submissions for the September 2008 edition of *CUPJ*. If you have an end of term research project or an article, please feel free to submit it to the *Canadian Undergraduate Physics Journal*. We are also seeking new and continued advertising subscriptions.

The September 2008 edition will have as a theme *careers for physicists*, and will include an article on Canadian women in physics as well as a number of papers from the UPPAC conference on 29th March 2008.

For undergraduates at Canadian universities *a mari usque ad mare*, believe me when I say that a fascinating and fulfilling future in physics awaits you.

Patrick

PATRICK BRUSKIEWICH
MSc, BSc, BEd
EDITOR IN CHIEF
cupj@cupj.ca