Sajeev John—Recipient of 2014 Canada Council Killam Prize

Sajeev John is the recipient of the 2014 Canada Council Killam Prize for his work on the localization of light and the invention of new Photonic Band Gap (PBG) materials. The Killam Prize was created to honour eminent Canadian scholars and scientists actively engaged in research. We sat down with Sajeev and asked him some questions about his background, research and being the recipient of this prestigious prize.

When did you first realize that you wanted to pursue physics as a career?

I was told that Physics is more a calling than a career. I enjoyed physics as a high school student but my grade 11 Physics teacher, Mr. Duncan, administered a terribly tough midterm test that I barely passed. This was not an auspicious start for the son of a physics professor. My biochemist mother, who preferred me to pursue a real career in medicine, would nevertheless not let me ignore any misstep and ensured that I more than compensate for this by the final exam. Perhaps, she overdid it. However, mastery of high school physics at Banting Secondary School in London, Ontario offered no surety that I could succeed internationally at the next level. I would unexpectedly discover this after my first year of studies at MIT.

Tell me about where you did your undergraduate degree.

MIT collected high school valedictorians from around the world and immersed us in a crucible aimed more to dissuade the naive than to persuade the masses to a career in physics. My freshman physics instructor at MIT was Bob Birgeneau, who later came to be President at the University of Toronto. I remember him calling freshman such as I, sitting unnoticed near the back of the classroom, to come forward and extemporaneously attempt to solve difficult problems, in front of the entire class, from the classical mechanics textbook of Kleppner and Kolenkow. As I stood unprepared in front of my peers, I wondered how I could pull off such a feat! I went to MIT expecting that my naïve idealism for physics would finally be laid to rest and that my mother's more practical wisdom about medicine would prevail. Instead it was an exceptional educational experience that reinforced both for me and my parents that a future in physics was not out of the question. I went on to do my undergraduate thesis in nuclear theory in MIT's Center for Theoretical Physics and then apply to graduate school. I was surprised one day, while waking up in my MIT dormitory room, to receive a personal call from Nobel laureate, Philip Anderson, asking what he could do to convince me to accept Princeton's Putnam Graduate Scholarship over equally appealing offers from Harvard, MIT, Stanford, Berkeley, and Caltech.

At Harvard, your PhD thesis outlined the theoretical framework for light localization PBG materials. What drew you to this topic?

The resounding achievements of Solid State Physics drew me to the subject of condensed matter theory. At Harvard, I discovered to my dismay that I was late to that party. The feast was wrapping up and the remaining research topics seemed insignificant by comparison. Against this backdrop, the condensed matter theory group offered only mixed encouragement. In retrospect this was a great blessing in disguise. It led me to interact with Michael Stephen, a Visiting Professor at Harvard, who would become my PhD thesis advisor.

Professor Stephen was a genuine theorist of unpretentious humility, with a warm smile and a kind spirit. He treated me from the outset as a scientific colleague rather than a student. He encouraged me to find my own field, unencumbered by previous footsteps. I was soon able to develop a theory for the localization of classical waves, based in part on analogy with electronic Anderson localization, which would constitute my PhD thesis. I published, on my own, the idea of trapping light. Two years later, Philip Anderson invited me to join the Physics Faculty at Princeton where I was able to confirm my idea and introduce the concept of light-trapping photonic band gap materials.

Tell me some real world applications of PBG materials that our readers would find really cool and interesting.

Photonic band gap (PBG) materials have applications in information technology, energy conversion, and clinical medicine to name a few. The PBG provides the basis for microscopic circuits of light on a chip. Since one beam of Laser light can pass freely through another, a given circuit path can simultaneously convey hundreds of independent wavelength channels of optical information. This is an improvement over electronic circuits that carry only a single channel of information. As electrons flow through a circuit path, they encounter resistance and their energy is dissipated in the form of heat. Electronic supercomputers require large cooling systems to carry this heat away and prevent the system from melting down. In an optical computer, based on PBG materials, light would not encounter such resistance nor generate such heat.

Photonic band gap fibres are presently used for delivering high intensity laser light through a flexible endoscope for cancer therapy. Here light is guided through a hollow fibre core using the light-localization, wave interference effect. In a standard solid core fibre, the high intensity of light would damage the fibre itself. The first life-saving procedure was performed in 2004 and today over 10,000 similar procedures have been carried out. On the horizon is another application of the photonic band gap chip in medical diagnostics. Optical "lab-on-chip" biosensors are poised to replace traditional time-consuming laboratory testing of human protein samples and can diagnose disease in an instant.

A potential large scale application of photonic crystals is for solar light trapping in ultra-thin silicon solar cells. These next generation solar cells are poised to surpass previous power conversion efficiency records, using roughly a factor of 500 less silicon than present-day cells.

When you joined U of T in 1989, you (along with U of T chemistry professor Geoffrey Ozin, U of T physicist Henry Van Driel and a team of scientists from Spain) built a silicon based PBG material. Tell me more about this and its implications.

While many photonic band gap materials had already been synthesized in labs around the world, this multidisciplinary collaboration demonstrated a new approach to microfabrication using the methods of self-assembly and chemical vapor deposition. This means that certain types of PBG materials can be manufactured on a large scale at very low cost. This also shows that important and unexpected milestones are made possible when scientists from diverse backgrounds work in concert with each other.

What do you find most fulfilling about your research?

It is exciting to start with a fundamental concept in physics and bring it to fruition in a variety of vital application areas. Sometimes cutting edge Physics requires extremes, either extremely high energy, extremely low temperature, extreme isolation, or extreme abstraction. It is fulfilling to work in a subject that breaks free of such limitations and can make a difference in more people's lives.

Tell me what this Killam Prize means to you?

I am grateful to the Canada Council for the Arts for recognizing my scientific efforts and I am indebted to the Killam family for the legacy they leave to Canada's intellectual growth and future prosperity. The Killam Prize is an encouragement for me to continue my endeavour and bring the subject of photonic crystals to further fruition. It is an inspiration to perpetuate the kind and generous spirit of Izaak and Dorothy Killam through purposeful science that can serve society.

Congratulations Sajeev!

His Excellency the Right Honourable David Johnston, Governor General of Canada, presented the 2014 Killam Prize to Mr. Sajeev John during a ceremony at Rideau Hall, in Ottawa, on May 26, 2014

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Physics Flashback — From the March 1997 Physics Newsletter

In 1997—Henry Van Driel from the Department of Physics was the recipient of the Killam Research Fellowship

Congratulations to Professor Henry Van Driel. He has won a Canada Council Killam Research Fellowship! This fellowship is one of Canada's most distinguished research awards. Professor Van Driel's area of research is quantum optics and he one of only nine new Killam Research Fellows. This award allows scientists to devote as much as two years to full-time research.