

MISSION: OUTREACH – THE WHY AND THE HOW OF IT

BY JOHN MATLOCK AND GREG DICK



Motivated by James Maxwell's equations describing electromagnetic radiation, Heinrich Hertz constructed a machine that could make a spark jump between two metal prongs separated by a finger's width. On the far side of a room he placed a single loop of wire. Heinrich carefully cut a narrow gap into his wire loop and suspended it with some string. He then energized his spark generator, which rhythmically zapped out a series of tiny sparks between the two metal prongs. Returning to the wire loop across the room, he bent down, moved in close and inspected the little gap in the wire. There it was, a tiny spark jumping from one edge to the other. Energy was traveling through the air, across the room, from his machine to the receiving wire loop. It was transmission and reception of electromagnetic energy just as Maxwell's mathematics had predicted. The date: 1887.

As the story goes, Heinrich shared the discovery with his class of University of Karlsruhe physics undergrads. After witnessing this seemingly magical transmission of energy through space, one of his students excitedly asked what

was next. What did the future hold for this amazing property of nature so freshly unearthed?

Heinrich responded, "Nothing, I guess."

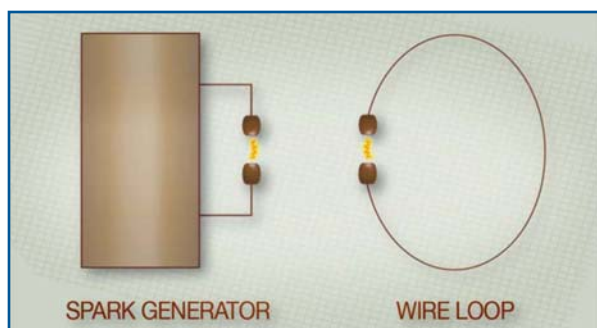
His response typifies two distinctly different, but equally profound, aspects of theoretical physics. First, the joy of chasing our universe's many mysteries is reason enough to commit a lifetime to the task, and second, it is not immediately obvious, even to their discoverers, what transformative uses new theoretical advances may turn out to have. But as history shows, the impact will follow.

RECOGNIZING THE NEED FOR SCIENTIFIC OUTREACH

Sharing the mystery, splendour, and importance of scientific research is one of the cornerstones of Perimeter Institute's mission, and has been from the outset. Content for students, teachers and the general public not only conveys cutting-edge ideas in science, but underscores the inherent power of theoretical physics and how basic research is essential to our long-term economic and social prospects as a society. The core scientific values - of curiosity, reason, creativity, critical enquiry, and the open exchange of information - can provide anyone with the skills and habits of mind needed to build a better future for themselves and others.

It seems intuitive that a scientifically literate population is an advantage for any nation, and that as the world becomes more inextricably tied to technology and the science behind it, the need for aggressive, systematic outreach becomes imperative. As NASA and CERN have demonstrated, the value to society of space exploration or high energy proton-proton collisions is not immediately obvious to some, until outreach and science communication operations bridge gaps to make the research accessible. Today, both organizations produce high quality materials explaining the basic science behind their various research activities, and showcasing the large and surprising array of spin off technologies arising from them—including food preservation techniques, Velcro, fuel cells and even the Internet.

The sharing of information on modern physics at PI includes this broader context. So in tandem with learning about specific theories, we hope to give audiences an appreciation of the ability of the human mind to explore the fundamental nature of the universe and how, in time,



John Matlock
<jmatlock@perimeterinstitute.ca>
Director of External Relations and Communications,
and
Greg Dick <gdick@perimeterinstitute.ca>
General Manager of Outreach

Perimeter Institute for Theoretical Physics,
31 Caroline St. N.,
Waterloo, ON
N2L 2Y5

SUMMARY

Theoretical physics has, and will continue to, transform society. Perimeter Institute's three-fold outreach focus is to communicate the importance and power of theoretical research, to develop brilliant young Canadians for the field, and to serve as an international resource for outreach expertise. Perimeter's Outreach programing and resources are designed to engage students, teachers and the general public. Share the experience by visiting www.perimeterinstitute.ca.



the pursuit of new understanding can give rise to a wide range of benefits and potent new technologies.

THE PI APPROACH TO HIGH-IMPACT OUTREACH

Perimeter Institute's three-fold outreach focus is to communicate the importance and power of theoretical research, to develop brilliant young Canadians for the field, and to serve as an international resource for outreach expertise.

To do so, the Institute provides a combination of programming and resources. Programming involves face-to-face interactions with PI outreach staff and scientists. Resources include hands-on kits and digitized offerings. The content within individual programs and resources typically falls into one of two categories that we think of as 'inspiration' and 'exploration'. Inspirational content opens your mind to the mysteries and wonders of the universe, setting the stage for research and discovery. The exploratory strand of content is much more challenging and provides a deep dive into abstract ideas in far more technical and mathematical detail, providing a rigorous experience for those who are beginning to ponder the same mysteries as leading physicists.

A small PI Outreach team creates all of the programming and resources by collaborating with our resident scientists, who ensure the content is accurate and cutting-edge. In the meantime, a growing team of teachers across Canada share their insights and expertise on the content - from inspirations to explorations - and assist the PI outreach team in converting the messages into pedagogically sound presentations and resources.

YOUTH AND TEACHERS

Perimeter Institute programming reaches youth across Canada through on-site visits and special science camps held at PI. The trips to high schools, science fairs and public festivals provide the inspirational content through 'Physica Phantastica' sessions, while the deeper exploratory content is delivered through 'Go Physics' on-location workshops. PI Outreach's staff, which includes two researchers turned educators with strong backgrounds in general relativity and quantum theory, provide many of the presentations. The most interested and engaged youth have the opportunity to visit PI during the International Summer School for Young Physicists (ISSYP). This annual science camp attracts talented high school students from across Canada and around the world to the research centre in Waterloo, Ontario for an intensive, two-week program that includes lectures on Einstein's ideas and the quantum world, mentorship from PI scientists, an introduction to the most profound unsolved puzzles of 21st century physics, and visits to labs such as SNOLAB. Because this camp comes at a time when scientifically-minded students are actively considering their career paths, the experience can be life-changing.



Developing youth for the field at ISSYP.

"I give credit to this program for giving me the self-confidence to believe I could become a physicist and putting me on the path I am on. It showed me that there is no reason not to try."

- 2008 ISSYP participant

Perimeter Institute also connects with teachers through a range of workshops that take place across the country and in our own research facility. The 'EinsteinPlus' science camp is held at PI every summer to provide educators with an opportunity to learn about the latest developments in frontier physics. Over the years the program has attracted teachers from every region of Canada as well as international participants from over 20 countries. Teachers grapple with fundamental questions: What are the deeper insights we want our students to have? How do we inspire students to enter the world of scientific exploration? The range of activities provides ample time for them to deepen their understanding of key concepts and discuss science education tools and techniques with the researchers and outreach staff at PI.

Given that the reach and capacity of the teacher and student workshops is inherently limited by the number of events our two outreach presenters can provide plus the actual room to accommodate participants at various locations, we began creating and distributing educational products that offer 24/7 benefits. These in-class resources, known as 'Perimeter Explorations', provide an efficient and ongoing avenue to share the wonder of science. The first two modules, entitled *The Mystery of Dark Matter* and *The Challenge of Quantum Reality*, are classroom-ready kits consisting of a custom produced 30-minute DVD presentation featuring leading scientists, and an accompanying Teacher's Guide containing supplementary information, student worksheets, and hands-on activities. The kits are designed to integrate into existing curricula, while proving opportunities for teachers to share cutting-edge physics that will challenge and motivate their students. Over 100 teachers and researchers contributed to the creation of these modules, which were then classroom tested with thousands of students. Designed with both expert and novice teachers in mind, the modules are in high demand by educators. Follow-up research shows that the lessons are now reaching hundreds of thousands of students year over year across Canada and beyond.

“My students love it when I go over the quantum aspect of physics and they are quite curious about it. I could never have conveyed the excitement of theoretical and quantum physics without my experiences at PI. Likewise, my modern physics presentations to the general public (teachers, parents and students of all ages) would not have been so well received.”

- Julie Lemay,
École Voyageur
Cold Lake, AB

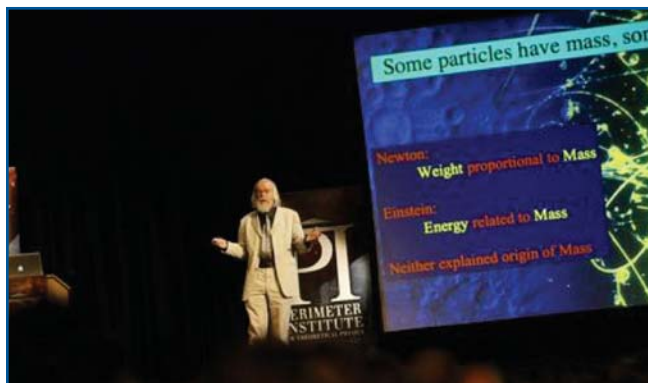


Engaging with educators and building the PI Teacher Network.

Engaging with teachers through workshop programming and resources is proving to be the most effective way for PI to reach large numbers of youth and help lead Canadian society toward an increased awareness and appreciation for the power of theoretical physics. To this end, the Institute is now developing a potent PI Teacher Network. This group of leading high school educators, drawn mainly from our EinsteinPlus science camp alumni, now spans across Canada. Members not only provide crucial pedagogical insights as new resources and programs are developed, they workshop PI’s existing resources for fellow teachers at home during their local professional development days. Those participants then receive full kits and, in turn, deliver the information on modern physics to their students year over year. The network is also an avenue by which PI’s expertise can transfer into provincial curricula and textbooks. The overall “train-the-trainer” approach keeps PI’s student and teacher outreach efforts focused on the science and sound pedagogy, while scaling its reach and impact in partnership with like-minded educators who embrace the instruction and professionally produced materials.

THE CANADIAN PUBLIC

PI outreach provides separate programming for members of the general public, who consistently demonstrate their appetite for



PI Public Lecture Series, putting the power of theoretical physics into the spotlight.

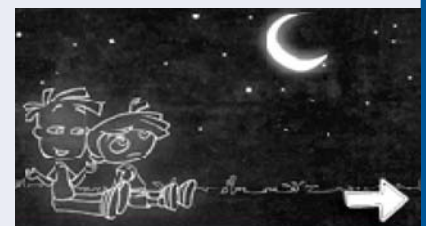
scientific knowledge. The flagship activity is the PI Public Lecture Series, in which visiting scientists are provided with an opportunity to share their love for research with an appreciative audience. Most events sell out within 30 minutes through an online booking system, filling a 600 seat theatre to capacity. The lecturers give eloquent and accessible insights into string theory, quantum gravity, cosmology, particle physics, quantum information and other research areas. Participating scientists have included Edward Witten, Frank Wilczek, Roger Penrose, Steven Weinberg, Nima Arkani-Hamed, Brian Greene, Lisa Randall, Gerard t’Hooft, John Ellis and may

others. In addition, PI programs some lectures to include more mainstream topics – ranging from digital animation techniques to the death of the dinosaurs – in order to draw new audiences in to learn about their world through a scientific lens. The events are professionally recorded and shared with wider audiences through partnering television and cable stations as well as on-demand viewing over PI’s website.

PI’s interactions with leading scientists, its experience in sharing abstract ideas in creative ways, and its fruitful partnerships with broadcast experts have carried one outreach project

INSPIRATIONS

In an effort to inspire people of all ages to the power of ideas, PI outreach member Dr. Richard Epp recently created a series of 60-second animations called *Alice & Bob in Wonderland*, which are available on YouTube and other video sharing sites and will soon be available in kit form for educators. Alice is a little girl brimming with curiosity, and each episode focuses on one of her questions, such as, “Why is it dark at night? What keeps us stuck to the Earth? Why can’t we walk through walls?”. Her older brother Bob defaults to quick and easy answers he has heard elsewhere, but his little sister’s unwillingness to accept superficial replies ends up challenging Bob to think “outside the box”. The cartoons are a whimsical way to awaken children and adults alike to the scientific mysteries around us. In an age where answers are generally no further away than Wikipedia, *Alice & Bob* focuses on where your own mind can lead you. It is a deliberate attempt to foster curiosity and critical thinking, which are, after all, the central ingredients of science.



Why is it dark at night?

Alice & Bob in Wonderland, opening our minds to the mysteries around us.



Quantum to Cosmos Festival, top down view of one location with panel discussion, audience and TV control room in the PI Atrium, beaming big thinkers and their ideas across Canada.

into prime time. A collaborative team has managed to convey the complexities of quantum mechanics through an entertaining made-for-TV documentary called *The Quantum Tamers: Revealing Our Weird & Wired Future*. This program for general audiences takes viewers deep inside the sewers of Vienna (the site of groundbreaking quantum teleportation experiments) and into high-tech quantum computing labs. Over a dozen leading scientists, including Stephen Hawking,

took part in the production in order to introduce concepts such as superposition and entanglement in novel ways that include the use of animation and even dancers. *The Quantum Tamers* has won several important international film festival awards and is now being distributed to television networks and education groups globally.

Another activity for the general public involves special events, such as the *Quantum to Cosmos: Ideas for the Future* festival. This activity was held in October 2009, to mark the tenth anniversary of PI, contribute to Canada's National Science and Technology Week, and help celebrate the International Year of Astronomy. The scope and scale of events included public lectures, panel discussions, science-in-the-pub talks, cultural activities, a sci-fi film festival, an art exhibit and a hugely popular 6,000 ft² exhibit centre filled with demonstrations, hands-on activities, physics experiments, an immersive 3D tour of the universe, a scale model of the next Mars rover and much more. The ten days of inspiration and exploration attracted 40,000 to the various venues in Waterloo and, through web streaming and television broadcasts, reached over 1,000,000 viewers. The impact on this large number of participants was measured through formal online polls and informal on-site feedback. We particularly enjoyed this response received from a grade 12 student who wrote to say that after visiting the festival through the school program, she and some of her peers hosted their own "Science Play Day" for grade 9 and 10 students "to simply encourage them to take science after grade 10".

INTERNATIONAL RESOURCE

Although Perimeter's outreach activities primarily benefit youth, teachers and general public audiences across Canada, there is increasing interest from international audiences with similar interests in science as well as from formal organizations wishing to learn about or even partner with PI outreach. The Institute therefore digitizes all content – from programming such as the PI Public Lecture Series, to resources such as Perimeter Explorations in-class modules – and shares it online in a simple and efficient manner. International teachers, for example, are able to download class content in return for their contact information – such that PI outreach can remain in touch and follow-up in future with specific questions.

The outreach team also provides specialized presentations upon request and has provided a wide range of plenary sessions and workshops for organizations all around the world including the American Association of Physics Teachers, the Physics Teaching Resource Agents, the UK Institute of Physics,

EXPLORATIONS

Described by dark matter discoverer Vera Rubin as "... imaginative, artistic and scientifically valid", the Perimeter Explorations series fulfills the number one request from high school teachers across Canada who are seeking in-class content on modern physics in a flexible, comprehensive and simple format that can be used in classroom settings. PI Outreach member Dr. Damian Pope developed the modules for senior high school grades, and chose dark matter as the subject of the first module, since it is currently one of the hottest topics in physics and the module provides teachers with tools to show how dark matter was discovered, to explain why it remains a mystery, and to share the passion of scientists who are trying to discover what it's made of. The resources consist of a DVD featuring leading scientists, animating equations and charts, indexed chapters to stop/start as required; a teachers manual with curriculum links; student activities with hands-on demonstrations and worksheets; and an introductory article about dark matter. The DVD also contains an electronic Word version of the printed content so that teachers can tailor the handouts and questions to suit their individual classes. The in-class resource is presently available in kit form to Canadian educators and is accessible to international educators through a digital download.



The Mystery of Dark Matter educational resource, sharing technical content in highly visual ways.



PI goes on location at CERN and elsewhere upon request, sharing outreach expertise with international teachers

CERN Teachers Workshop, the American Association for the Advancement of Science and even a number of customized professional development events for science writers throughout the journalism community.

THE MISSION CONTINUES

Heinrich Hertz could not have known in 1887 that the phenomena he demonstrated as a simple curiosity to his students would usher in a new era of communication by the close of the next century. In today's day and age, PI is trying to spark audiences of all ages to the mysteries and importance of basic research – because sharing great ideas is one of the best ways to create new ones.

Educational Programs

Physica Phantastica
Go Physics
International Summer School for Young Physicists
EinsteinPlus Teachers Workshop

Teacher Resources

The Mystery of Dark Matter
The Challenge of Quantum Reality
Planck's Constant Activity
The Physics of Innovation

Public Activities

PI Public Lecture Series
Festivals & Special Events
The Quantum Tamers

Online Activities

Select programs & resources (above)
What We Research
The Power of Ideas
Meet a Scientist
Alice & Bob in Wonderland