



# STEP INSIDE THE PERIMETER

a year in review: 2016/17



STRONG  
GRAVITY

COSMOLOGY

MATHEMATICAL  
PHYSICS

QUANTUM  
INFORMATION

*"I've worked at fantastic places like Berkeley, Stanford, and CERN, but Perimeter is unique. Here it feels like my possibilities are endless."*

*– Asimina Arvanitaki, Stavros Niarchos Foundation Aristarchus Chair, winner of the 2017 New Horizons Prize in Physics*

## THE FUTURE STARTS HERE

Fundamental physics is more than an academic pursuit. It's one of the building blocks of society. Practically every technology we rely on today emerged from an earlier breakthrough in our understanding of the universe.

Maxwell's unification of electricity and magnetism underpins all wireless communications. Einstein's work on the quantum nature of light gave us lasers; his theory of relativity is essential to GPS. Marie Curie's work on radioactivity unveiled the workings of the subatomic world.

At Perimeter Institute for Theoretical Physics, scientists are pursuing the kinds of breakthroughs that will reshape our world. From the smallest subatomic particles to the entire cosmos, explorations in theory pave the way for transformative technologies.

This is a critical time. We are living in the most exciting period in physics in decades. Our ability to detect gravitational waves has opened a new window into the universe, enabling exploration of black holes, galactic structure, and the origins of the universe. Fundamental exploration of the quantum realm is driving powerful nascent technologies.

Big breakthroughs can come from anyone, anywhere. Perimeter strives to act as a beacon for global excellence. We welcome the brilliant and the curious, the learned and the learning. With extensive connections spanning theoretical research, experimental labs, technological development, venture capital, and early-stage entrepreneurship, Perimeter is helping to ensure that Ontario and Canada will be at the forefront of discoveries that will change the world.

*"Perimeter has successfully positioned Canada as a world leader in theoretical physics research."*

*– KPMG Independent Evaluation Report, 2016*



## ONE PLACE, ENDLESS POSSIBILITIES

For 18 years, Perimeter researchers have been at the forefront of developing new ideas about how the universe works. In the Institute's vibrant research environment, we gather the best minds – seeking out independence, originality, and brilliance – and encourage cross-disciplinary collaboration.

This approach fosters a dynamic flow of ideas among people and between specialties. It's a bold path that is leading to discovery. Asimina Arvanitaki, the Stavros Niarchos Foundation Aristarchus Chair, won the New Horizons in Physics Prize, the most prestigious prize for young scientists. She is the fifth Perimeter scientist to win the prize, more than any institution in the world.

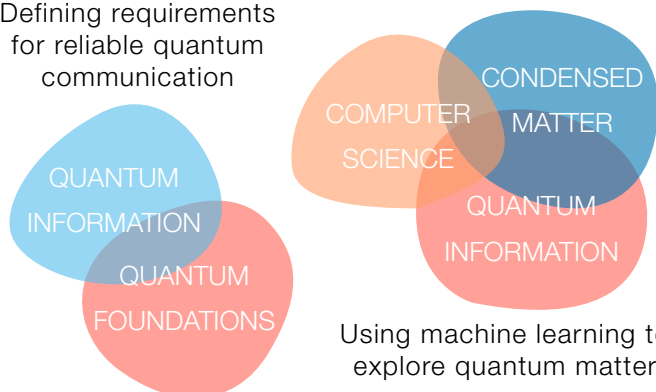
Perimeter researchers:

- Won 12 major honours and prizes in 2016/17, and were awarded over \$3.5 million in research grants
- Authored 502 research papers in the last year and had nine recognized as "Highlights of 2016" in several peer-reviewed journals
- Have produced over 4,600 papers in total, which have appeared in more than 170 journals, attracting well over 210,000 citations

*In 2017, it was announced that Perimeter Faculty member Kendrick Smith was co-awarded the \$3 million 2018 Breakthrough Prize in Fundamental Physics for his work on the Wilkinson Microwave Anisotropy Probe.*

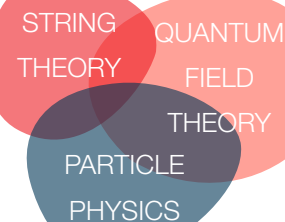
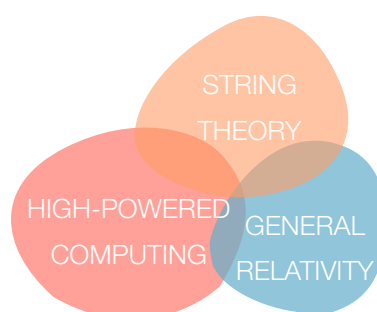
## POWERFUL PHYSICS INTERSECTIONS IN 2016/17

Defining requirements for reliable quantum communication



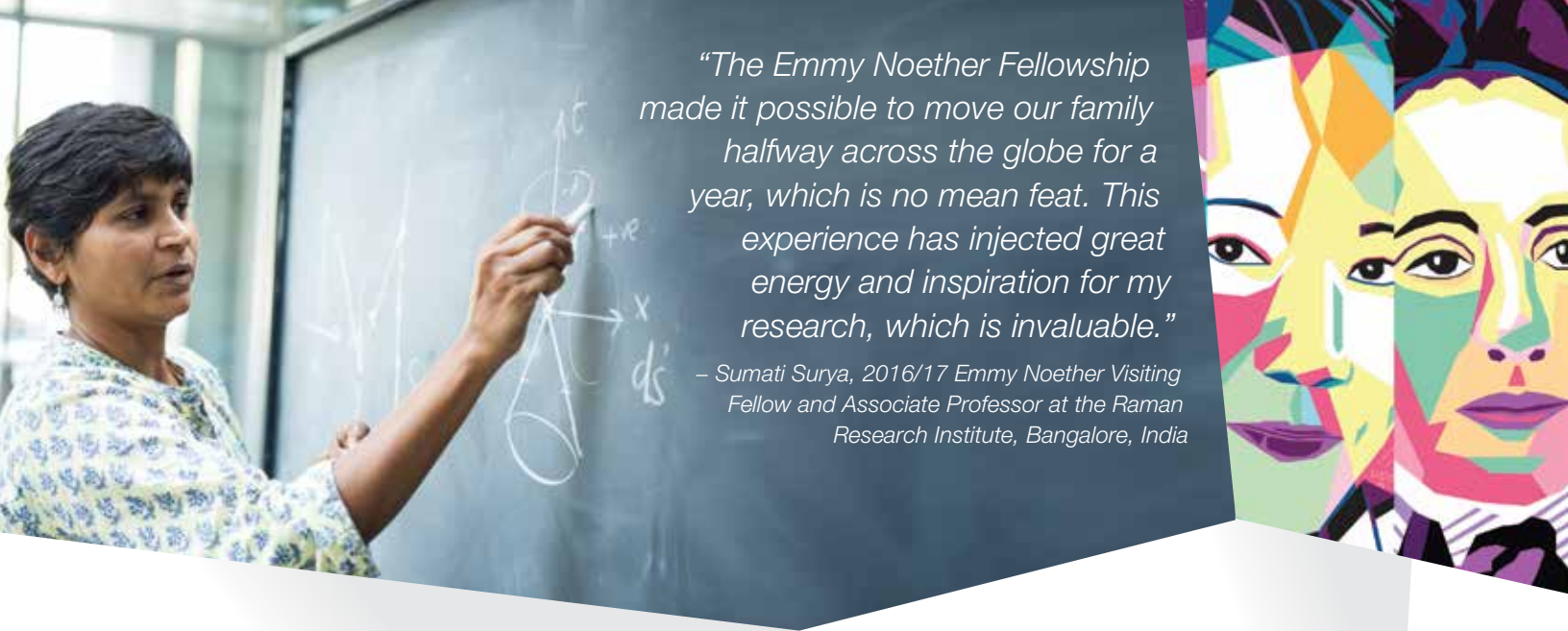
Using machine learning to explore quantum matter

Probing black hole collisions



Understanding the quantum constituents of matter





*"The Emmy Noether Fellowship made it possible to move our family halfway across the globe for a year, which is no mean feat. This experience has injected great energy and inspiration for my research, which is invaluable."*

– Sumati Surya, 2016/17 Emmy Noether Visiting Fellow and Associate Professor at the Raman Research Institute, Bangalore, India

## THE WORLD'S BRIGHTEST UNDER ONE ROOF

Perimeter continues to grow strategically, assembling clusters of cross-disciplinary expertise in areas identified as ripe for major progress. On any given day, about 150 researchers and students can be found in Perimeter's iconic building, working at chalkboards, collaborating over coffee, calculating, and devising new ideas and experiments to advance our understanding of the universe.

By enabling scientists to focus entirely on their research, Perimeter has been able to attract many of the world's most talented researchers. From early-career postdocs to eminent scientists, the Institute provides bold, ambitious researchers with the unfettered freedom and resources to push their work to new levels.

In 2016/17, the Perimeter community grew to include:

- 21 full-time faculty members (one new, three to come in 2017/18)
- 16 associate faculty, jointly appointed with partner universities (two new, one to come in 2017/18)
- 9 Perimeter Research Chairs (two new)
- 59 postdoctoral fellows (24 new)
- 54 Distinguished Visiting Research Chairs (six new)
- 34 Visiting Fellows (seven new)
- 10 Emmy Noether Visiting Fellows (eight new)
- 120 Affiliates from across Canada (eight new)

(Numbers in this report were current as of July 31, 2017.)

## A WORLD OF OPPORTUNITY

Perimeter seeks to discover and support new voices in global science. This year, Perimeter deepened its partnership with the South American Institute for Fundamental Research (SAIFR) in São Paulo, Brazil. The partnership facilitates scientific exchanges, joint conferences and training, and is developing outreach programs for Brazilian high school students and teachers.

Emmy Noether Initiatives support and encourage gender diversity in science, from high schoolers through senior faculty. A centrepiece of these efforts is the Emmy Noether Visiting Fellows program, which brings talented researchers to the Institute at a critical phase of their careers to work intensively on their research for periods of up to one year.



## COLLABORATION IS CRUCIAL TO NEW DISCOVERIES

Perimeter is a hub for global science. Each year, hundreds of visiting scientists come to do research, teach, lecture, and collaborate. Hundreds more participate in the Institute's renowned conference program. Topics in 2016/17 included: quantum machine learning, dark matter, quantum information, and the promise and challenge of devising small-scale particle physics experiments.

- 406 scientific visitors
- 308 scientific talks
- 20 conferences and workshops, attended by 867 scientists from around the world
- 11,000+ seminars, conference talks, and courses in Perimeter's searchable, citable video archive, [pirsa.org](http://pirsa.org), which were accessed by 108,966 visitors in the global physics community last year

## THE CENTRE FOR THE UNIVERSE

How did the universe begin? What are dark matter and dark energy? How do black holes work? Recent observations from cutting-edge experiments are transforming our understanding.

To take advantage of this golden opportunity, Perimeter has launched the Centre for the Universe with a \$5 million founding donation. This 10-year, \$25 million focused research effort will seek new answers to the deepest questions in cosmology. Led by Neil Turok, with Stephen Hawking and Nobel laureate Arthur McDonald as scientific patrons, the Centre is bringing together resident scientists, new recruits, and international experts to develop new theories, devise experiments, and analyze new observations.

Through partnerships with the Canadian Institute for Theoretical Physics (CITA) and the Dunlap Institute at the University of Toronto; the Centre for Astrophysics at the University of Waterloo; Queen's University; the University of Guelph; and York University, the Centre is also connected to key international experiments. These include the Laser Interferometer Gravitational-Wave Observatory (LIGO), the Canadian Hydrogen Intensity Mapping Experiment (CHIME), the Sudbury Neutrino Observatory (SNOLAB), and the Event Horizon Telescope (EHT).





## FINDING – AND FEEDING – THE GREAT MINDS OF THE FUTURE

Young minds are the future of discovery. Perimeter attracts exceptional young talents from around the world, offering rigorous and innovative scientific training that transforms students into scientists.

Perimeter Scholars International (PSI), jointly administered with the University of Waterloo, has become one of the most sought-after master's programs in theoretical physics worldwide. Over the last year, Perimeter's PhD program continued to grow, attracting outstanding students with unparalleled opportunities to interact with scientific leaders.

In 2016/17, Perimeter had 109 scientists in training:

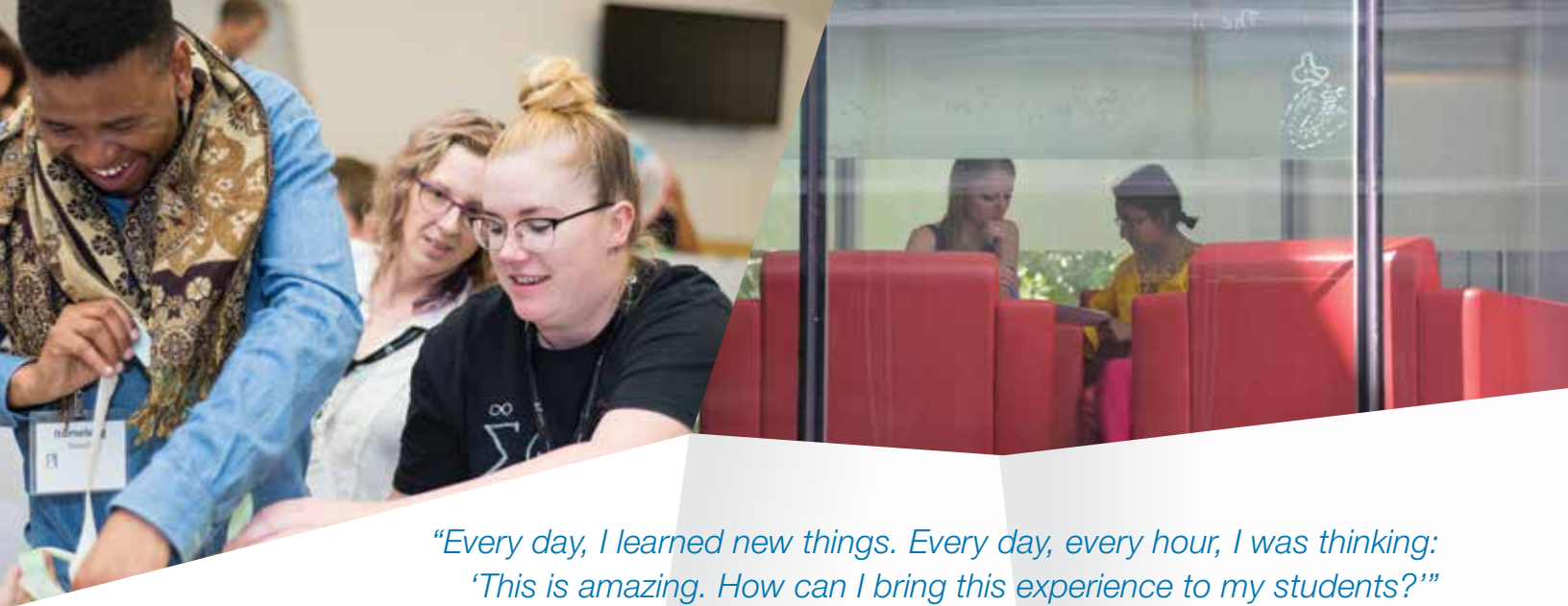
- 49 PhD students
- 28 master's students
- 32 Visiting Graduate Fellows

*Perimeter alumni are rising stars in research, high-tech entrepreneurship, industry, medicine, and beyond.*

## SHARING THE WONDER OF DISCOVERY WITH THE WORLD

Science is full of amazing stories and fascinating people. This year, we added a new platform for sharing science with the world: [insidetheperimeter.ca](http://insidetheperimeter.ca). With timely, in-depth articles, a library of over 300 videos, and the award-winning "Slice of PI" web features, [insidetheperimeter.ca](http://insidetheperimeter.ca) is adding to our rapidly-growing digital footprint.

The 13<sup>th</sup> season of the Perimeter Public Lecture Series transported audiences to the brink of discovery in person and online, with topics ranging from black holes to pulsars to the physics of Wall Street. Over 230,000 viewers watched Perimeter Public Lectures online. With over 400 videos, Perimeter's YouTube channel has 35,000 subscribers and garnered over 875,000 views.



*“Every day, I learned new things. Every day, every hour, I was thinking: ‘This is amazing. How can I bring this experience to my students?’”*

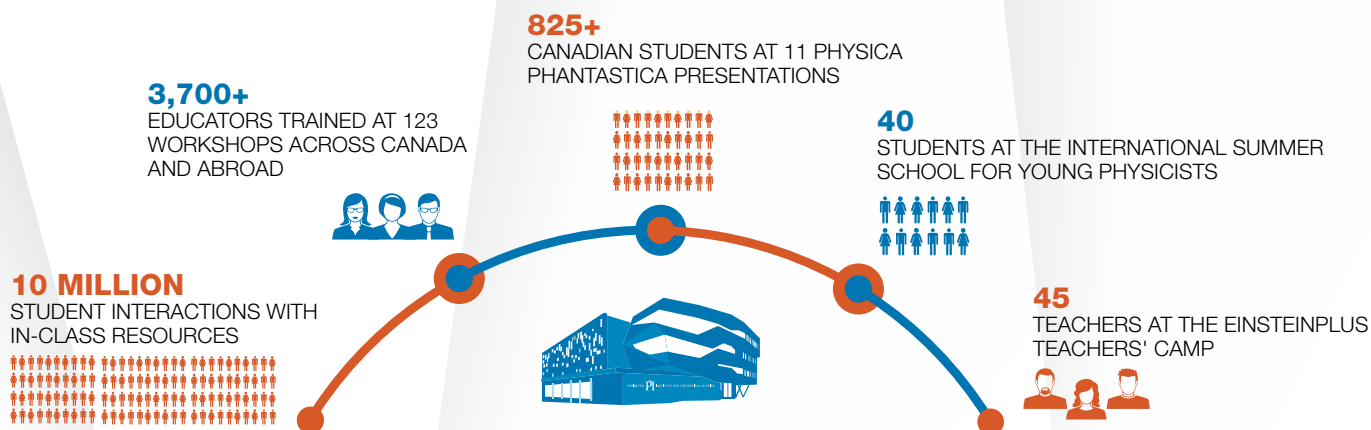
*– Rebecca Messer, physics teacher and EinsteinPlus attendee*

## INSPIRING THE NEXT GENERATION OF SCIENTISTS – AND THEIR TEACHERS

Tomorrow’s innovators will need creativity, tenacity, and critical thinking skills. Physics provides all that and more. Perimeter’s passionate Educational Outreach team creates in-class resources, delivers educational programs, provides teacher

training, and runs summer programs for outstanding students and educators. Perimeter’s global network of educators spans over 30 countries, and has trained over 20,000 teachers to date.

## INSPIRATION FOR ALL: 2016/17 BY THE NUMBERS



In 2017, Perimeter’s research and activities were covered by national and international media, including in:

**THE GLOBE AND MAIL**

**SCIENTIFIC  
AMERICAN**

**MACLEAN'S**

**The  
Economist**

**theguardian**

**GIZMODO**





## A YEAR OF “WOW!”

In 2017, Perimeter was proud to lead Innovation150, sharing the spark of innovation across the country for Canada's 150<sup>th</sup> celebration.

The Innovation150 program included major festivals, inspiring talks by Perimeter Director Neil Turok and Nobel laureate Art McDonald, online contests, travelling exhibits, pop-up maker stations, crowd-sourced stories, and more.

From mountain passes and ice roads to prairie heat and blazing fall colours, the Innovation150 partnership delivered a year of fun, fascinating science to Canadians of all ages.

## BY THE NUMBERS:

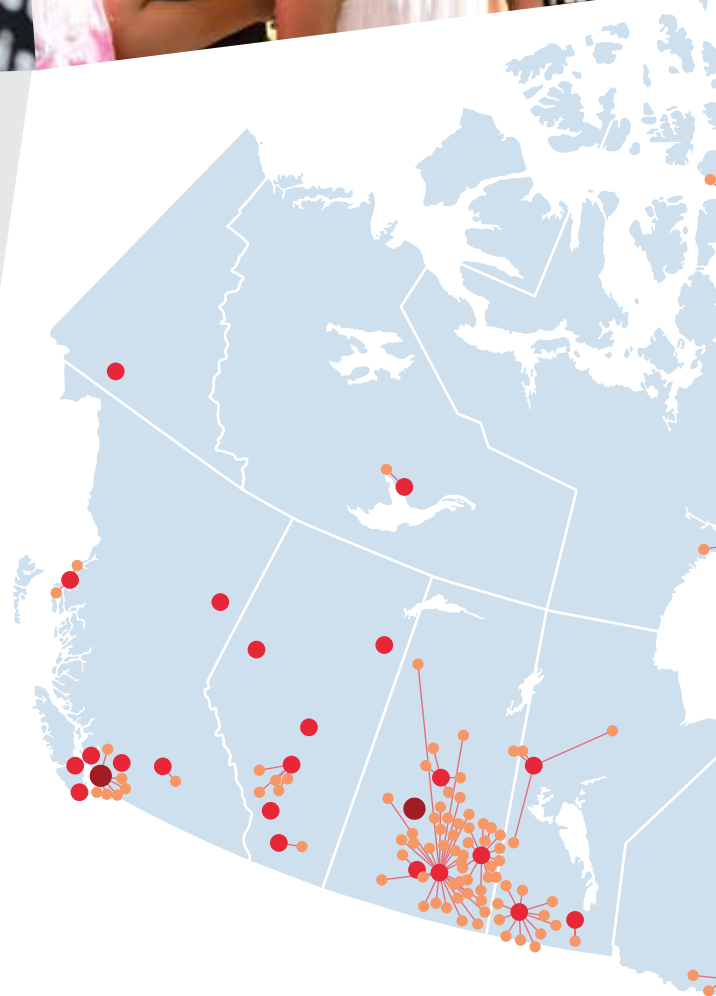
5 major innovation festivals

190+ communities

1,200+ classroom resources  
delivered to teachers

100,000+ Power of Ideas attendees

2.8 million+ online clicks,  
shares, and likes



Supported by the federal government through Canadian Heritage, Innovation150 was delivered through a partnership between Perimeter Institute, Actua, the Institute for Quantum Computing at the University of Waterloo, the Canadian Association of Science Centres and its members, Ingenium, and collaborations in every province and territory.





*“Innovation, in my view, is a process, not an outcome. It can be learned and cultivated in our society. Anyone can be a part of it and everyone should. It actually defines who we are, and where we are going.”*

– Neil Turok, in his “We Are Innovators” talk

## BEYOND 150...

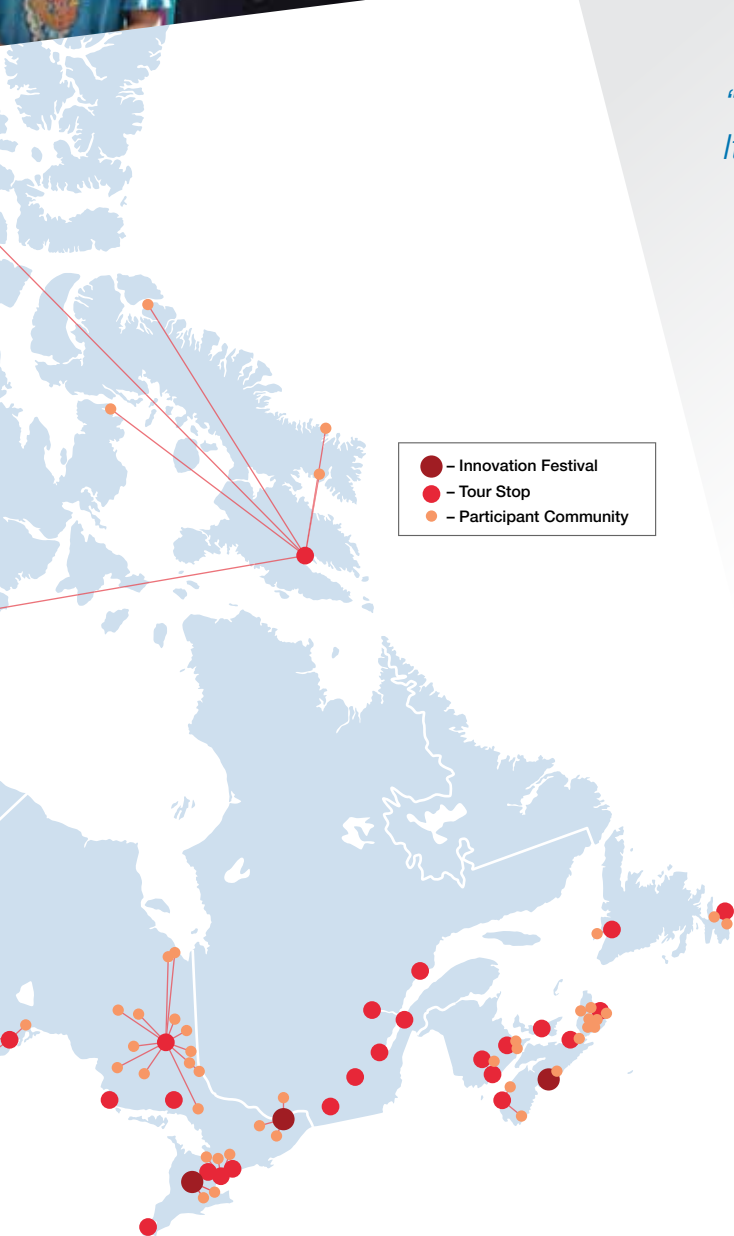
How can you study what you can’t see? How can we see black holes? Can you travel back in time through a telescope?

The Power of Ideas travelling exhibition got brains buzzing with big questions and hands-on learning in over 190 communities across Canada. It will continue to engage tens of thousands of youth through ongoing tour circuits for years to come.

Ideas and activities drawn from the exhibit will be transformed into new Perimeter classroom resources and online experiences, including a digital version of Neil Turok’s “We Are Innovators” talk and the InnovationCulture.ca website.

*“Usually, there’s not much science or exhibits in Yellowknife. Innovation and science go hand in hand. That’s how we keep moving forward with technology, and that’s how the world keeps on advancing.”*

– Bishal Yadav, Power of Ideas attendee





## OUR PARTNERS ARE CRUCIAL TO OUR SUCCESS

Through visionary public and private support, sound strategy, and sustained focus, Perimeter is now ranked among the top theoretical physics institutes globally. We couldn't do it alone.

As a non-profit, independent research centre, the Institute is funded through an innovative public-private partnership that shares the opportunities and benefits of long-term investment in fundamental research.

This year, the Government of Canada and the Province of Ontario finalized new five-year, \$50 million funding agreements, reaffirming their commitments to foundational science and recognizing that Perimeter is a strategic asset for science, for Canada, and for our future. Such strong support helps underpin and promote strong science.

*"It is difficult to conceive of a research institute of similar scope and size that would generate as much visibility and impact for every dollar invested in it as does the Perimeter Institute."*

*– 2016 Evaluation Report of Perimeter's independent Scientific Advisory Committee*

BMO Financial Group

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Gluskin Charitable Foundation

The Daniel  
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The Kitchener and Waterloo Community Foundation  
- Muttagee Fund  
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SUPPORTING THE SCIENTIST

MEMBERS OF PERIMETER LEADERSHIP CIRCLES

Emmy Noether  
Circle

Directors  
Circle

Accelerators  
Circle





## WORKING TOGETHER FOR A COMMON CAUSE

Perimeter strives to be a beacon of excellence. We cultivate partnerships that magnify our strengths, and gather great minds in a vibrant research community. We offer outstanding training, and welcome exceptional talents from every continent and any background. We share the passion and joy of discovery with the world, and aim to seed a brighter future for all.

This year, Perimeter surpassed a three-year target of raising \$25 million from the private sector, including individuals, corporations, and foundations. This year's gifts included a \$5 million founding

donation to launch the Centre for the Universe, gifts from Cenovus Energy and the Delaney Family, and a widening circle of other passionate individual supporters.

Discovery is our mission and our passion – and we are proud to share this with our many partners and supporters.

*"We are on the verge of major discoveries about the universe and its origins. I hope and expect many of those discoveries will be made at Perimeter."*

*– Stephen Hawking, Perimeter Institute Distinguished Visiting Research Chair and Scientific Patron of the Centre for the Universe*





IT'S A BIG UNIVERSE.  
FORTUNATELY, WE HAVE BIG IDEAS.



PERIMETER



INSTITUTE FOR THEORETICAL PHYSICS



[www.perimeterinstitute.ca](http://www.perimeterinstitute.ca)

Charitable registration number: 88981 4323 RR0001