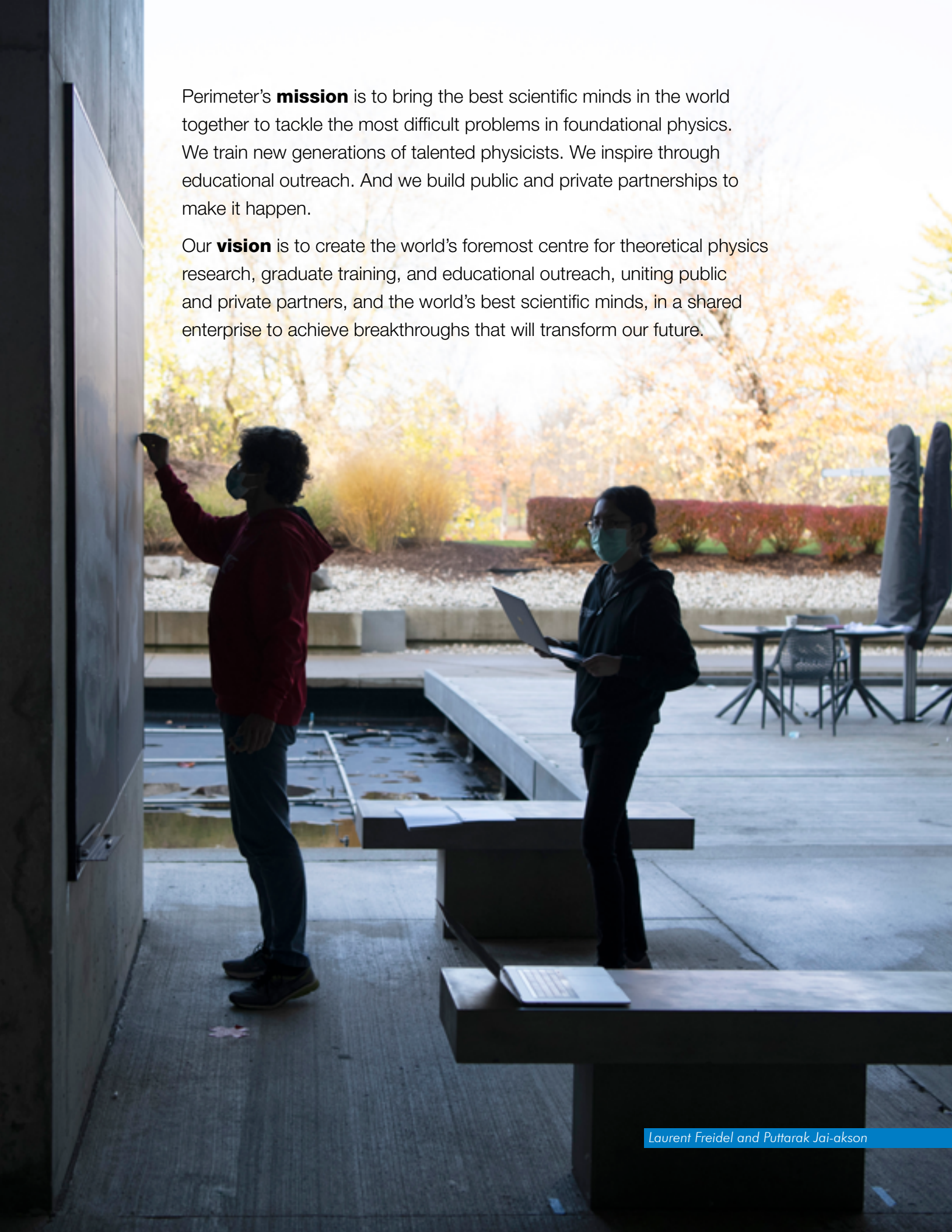


STEP INSIDE THE PERIMETER

a year in review: 2019/20

PERIMETER  INSTITUTE FOR THEORETICAL PHYSICS



A photograph of two individuals in a modern, brightly lit interior space. On the left, a person with curly hair, wearing a red hoodie and a face mask, stands with their back to the camera, pointing at a large whiteboard. On the right, another person wearing a dark jacket and a face mask stands facing the whiteboard, holding a laptop. The background shows a large window with a view of trees with yellow autumn foliage. The scene is lit with natural light from the window, creating a bright and airy atmosphere.

Perimeter's **mission** is to bring the best scientific minds in the world together to tackle the most difficult problems in foundational physics. We train new generations of talented physicists. We inspire through educational outreach. And we build public and private partnerships to make it happen.

Our **vision** is to create the world's foremost centre for theoretical physics research, graduate training, and educational outreach, uniting public and private partners, and the world's best scientific minds, in a shared enterprise to achieve breakthroughs that will transform our future.

WHO WE ARE

Perimeter Institute for Theoretical Physics is an independent research institution dedicated to the big questions of our field: What is the universe made of? How did it begin? How does it work? And how can we harness these understandings to create better technologies, deeper connections between people, and a brighter future for our world?

Perimeter is not a place for “business as usual,” incrementally advancing science. We pride ourselves on doing fearlessly ambitious work. We attack tough problems from multiple angles, and we recognize when conventional approaches are failing. We open and explore new avenues. We constantly challenge ourselves to be interdisciplinary, agile, and entrepreneurial.

This year, Perimeter’s Scientific Advisory Committee, an independent panel of international scientists, reviewed the past five years of Perimeter’s work. Here is some of what they found:

“Perimeter is unique in the scientific landscape, with a forward-looking, innovative, collaborative and inclusive climate. It has greatly raised Canada’s reputation in the field of high-level theoretical physics and has shown a very high return on government investment, and at a fast pace.

“PI has stayed true to its inspiring and ambitious founding mission while adapting to new opportunities and changing times. Institute scientists have made a number of landmark discoveries in several different research areas, and an increasing number of very talented and diverse young scientists have emerged from its training programs.

“Perimeter has major research strengths in several exciting areas of physics that are likely to see major advances, and others that will be realized in new technologies. The institute is well-positioned for growth in these areas, and potentially to make important, long-lasting contributions to science and technology.”

Another independent review of Perimeter’s research by Clarivate Analytics found that it is extremely high quality, with high impact on the global research community. It also showed that Perimeter is vital to Canada’s leading position among G7 countries in physics and space science.

As we approach our 20th anniversary, Perimeter stands as a driving force that lifts all of Canadian physics, a global hub that accelerates scientific progress, and one of the best centres for theoretical physics in the world.



Sergey Sibiryakov



Mairi Sakellariadou, Sylvie Paycha, and Renate Loll at the “Emmy Noether Workshop: The Structure of Quantum Space Time,” November 2019

RESEARCH BY THE NUMBERS

Perimeter has built one of the world’s largest and strongest communities of researchers in fundamental physics.

RESEARCH COMMUNITY

- 46 Faculty and associate faculty members
- 42 Distinguished Visiting Research Chairs
- 84 Postdoctoral researchers
- 25 Simons Emmy Noether Fellows (8 new in 2019/20)
- 55 Visiting Fellows
- 7 Visiting Researchers
- 12 conferences and workshops attended by 995 of the world’s top scientists

OUTPUT AND IMPACT

- 20 major prizes and honours in 2019/20
- 6,282 papers published since Perimeter’s inception
- 743 papers published in 2019/20
- 290,360 citations since inception

“Right now, the world needs radical solutions. Not slightly better batteries, but whole new sources of energy. Not slightly optimized algorithms, but whole new ways of computing. These solutions require a new wave of fundamental discoveries from new generations of brilliant researchers. Perimeter recruits and trains scientists with the skills, drive, and vision to make these kinds of ambitious discoveries. That’s how you build a world-leading research institute. And it’s how you change the world.”

– Robert Myers, Director

RESEARCH BEYOND THE NUMBERS

HIGHLIGHTS

This year, we produced stunning new results in quantum matter, quantum simulation, and quantum field theory, and foundational work on the nature of time itself. Perimeter researchers and their collaborators released the largest ever 3D map of the universe and participated in major new work from the Event Horizon Telescope and the CHIME telescope.

We launched the **Clay Riddell Centre for Quantum Matter**, devoted to studying and creating new states of matter with properties that continually push the boundaries of what is possible in materials science. New quantum materials will revolutionize technology, drug discovery, and many other branches of applied physics.

Perimeter's new Quantum Causal Inference Lab capitalizes on remarkable new insights from foundational quantum theory to determine causal relationships within highly complex systems. It has the potential to transform epidemiology, finance and insurance, risk modelling, and many other branches of fundamental science.

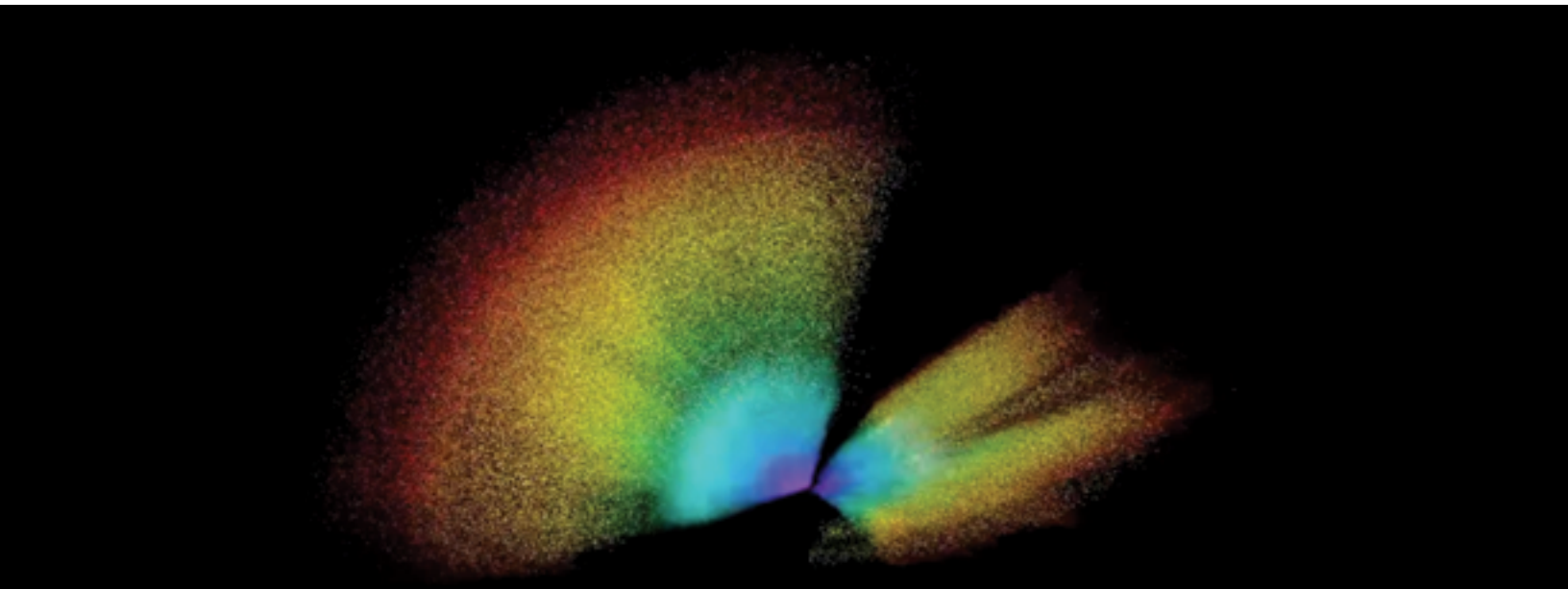
A GLOBAL HUB FOR PHYSICS

Perimeter accelerates research with can't-miss workshops and conferences. In 2019/20, almost 1,000 scientists from around the world participated in 12 conferences and workshops hosted by Perimeter. During the pandemic, we moved all conferences online and quickly became an international model for high-impact virtual conferences, with large increases in attendance.

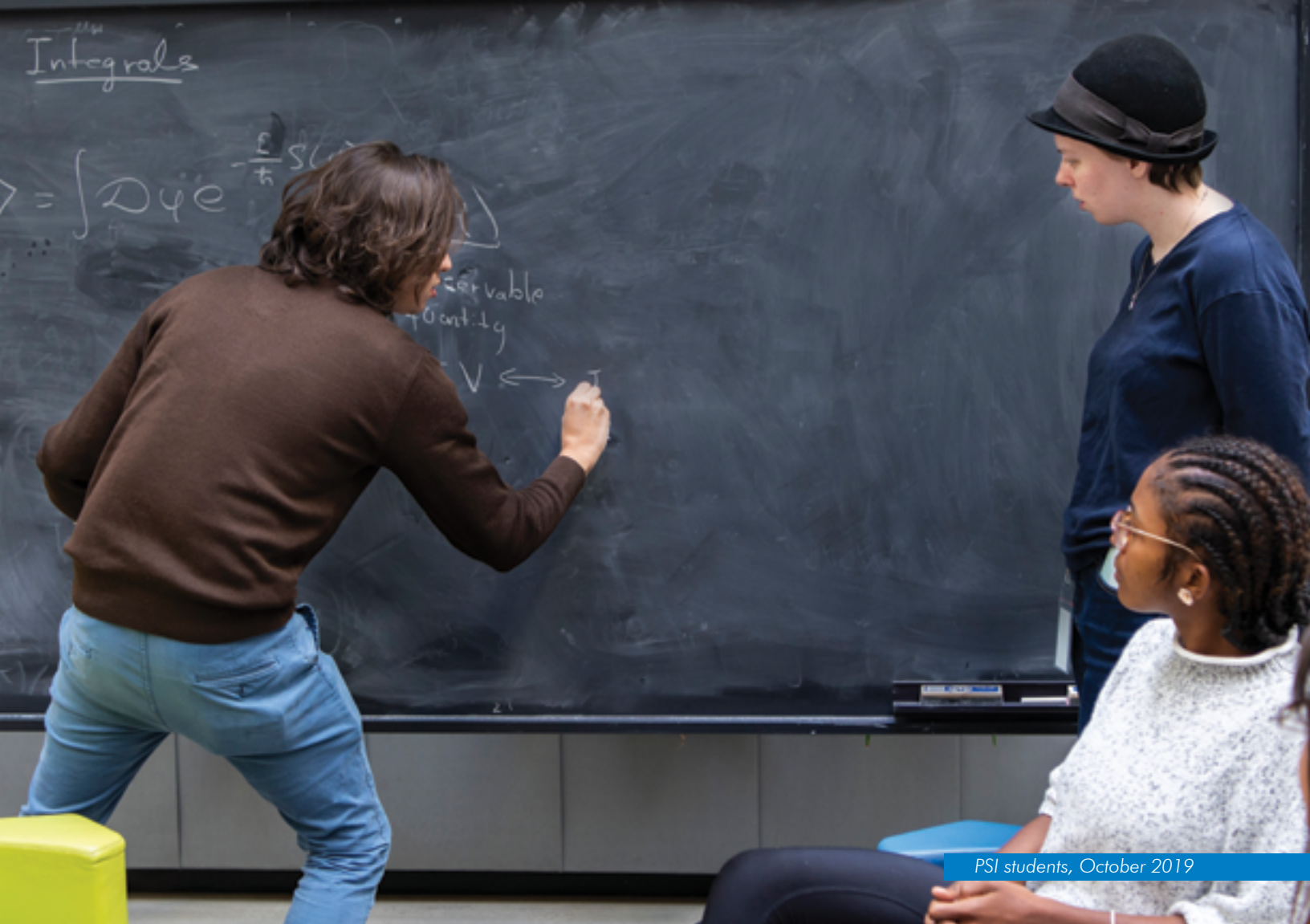
We also built on our digital archive of more than 13,000 recorded lectures and conference talks to create SciTalks, a new global hub for talks and presentations from research institutions around the world. Visit [SciTalks.ca](https://scitalks.ca) to find out more.



Perimeter's Kendrick Smith helped create the algorithms that power Canada's innovative CHIME telescope. During the pandemic, he applied those technical skills to help researchers at Sunnybrook Hospital and McMaster University develop a software pipeline for the genetic sequencing of COVID-19 virus samples. Other Perimeter researchers developed mathematical models for understanding community spread, for developing smarter testing schemes, and for guiding the distribution of vaccines. It's a dramatic example of how widely applicable the technical skills of physicists can be.



The largest 3D map of the universe shows 11 billion years of the universe's history, with galaxies closest to Earth appearing in purple and blue, and distant galaxies in yellow and red. (Image © EPFL)



TRAINING BY THE NUMBERS

Since 2006, Perimeter has trained more than 1,000 young scientists.

CURRENT LEARNING COMMUNITY

- 84 Postdoctoral researchers
- 77 PhD students from 33 countries
- 26 Associate PhD students
- 19 Visiting Graduate Fellows
- 26 PSI master's students from 17 countries, including 13 women
- 54 undergraduate summer school students from 21 countries, including 20 women



We moved our graduate programs online almost overnight in March 2020. We are proud that all of those students scheduled to graduate successfully completed their courses. Our undergraduate summer program also moved online, and because we did not need to house or fly students to Waterloo, we were able to double the number of talented participants.

TRAINING BEYOND THE NUMBERS

GRADUATE PROGRAMS THAT TURN STUDENTS INTO SCIENTISTS

Perimeter trains the next generation of brilliant minds for leadership roles not just in physics, but anywhere complex problems need bold solutions. Our innovative research training — including our renowned PhD and Visiting Graduate Fellows programs — attract top scientific talent, increase their expertise, advance research, and produce job-ready leaders capable of driving research progress and economic growth.

Our flagship Perimeter Scholars International program puts 25 to 30 of the world's most talented master's students through a challenging, collaborative program that covers the full breadth of theoretical physics in just nine months. The program is highly competitive: the 13 women and 13 men in the 2019/20 cohort were chosen from 688 applicants.

POSTDOCTORAL POWERHOUSE

Perimeter has one of the world's largest communities of theoretical physics postdocs. These early-career scientists, often at the height of their creativity, pursue ambitious research with total research freedom and mentorship from senior scientists. These positions are highly sought after: the 25 postdocs who joined Perimeter in 2019/20 were selected from 700 highly qualified applicants.

SEEDING CANADIAN INDUSTRIES

Many of our alumni adapt their problem-solving, mathematical, and other skills to create and innovate in finance, cybersecurity, data science, artificial intelligence, biomedicine, quantum technologies, and many other economic sectors.



Ke Cai
Scotiabank
Senior Manager Enterprise
Stress Testing, Toronto



Gunjan Lakhiani
Royal Bank Canada
Machine Learning
Enterprise Mgt.,
Toronto



Solomon Owerre
Loblaws
Senior Chief Data
Scientist, Brampton



Chenfeng Bao
Desire2Learn
Software Developer,
Kitchener



Kyle Tate
Shopify
Director of Data
Science, Ottawa



Pedro Ponte
BMO Capital Markets
Associate Trading Data
Scientist, Toronto



Alexandre Yale
**Touchstone Intelligent
Marketing**
Co-Founder & CDO,
Montreal



Shreya Kumar
Xanadu
Data Scientist,
Toronto



Jorge Escobado
Drop
VP Engineering,
Toronto



Kim-Tuyen Hoang
Oz Optics
Optical Engineer,
Ottawa

“Physics doesn't have a monopoly on hard, unsolved problems, but it does routinely produce people ready to tackle them. The world needs physicists.”

— Alexander Radovic, Perimeter alum, now working as a machine learning researcher at Borealis AI



OUTREACH BY THE NUMBERS

The classroom resources and public events Perimeter organizes reflect our belief that great science deserves to be shared with the people whose lives it touches — and that's everyone.

STUDENTS

- 59,018,050 interactions in classrooms since 2006
- 6,828,250 interactions in classrooms in 2019/20
- 956 students attended presentations in 2019/20
- 155 students attended “Inspiring Future Women in Science” in 2020
- 40 exceptional high school students — 18 Canadian, 22 international — attended the 2020 International Summer School for Young Physicists

TEACHERS

- 35,688 teachers reached globally by Perimeter’s Teacher Network
- 4,507 teachers trained at 200 workshops in 2019/20
- 67 teachers attended EinsteinPlus teacher training camp in 2019/20
- 118 countries in which Perimeter educational resources have been used
- 110 in-class science resources available to teachers across Canada and around the world
- 25 resources translated into French

SCIENCE FOR THE WORLD

- 6 public lectures were viewed online 745,752 times in 2019/20
- 2,819,007 YouTube views in 2019/20
- 10,578,792 YouTube views since 2009

“Its remarkable outreach programs bring the adventure of discovery to students of many ages and may well incubate a new generation of Curies and Einsteins.”

— Final Evaluation Report, Perimeter Institute Scientific Advisory Committee, October 2020

OUTREACH BEYOND THE NUMBERS

TRAINING FOR TEACHERS

Perimeter's outreach programs are particularly committed to reaching students — and it starts with reaching their teachers. EinsteinPlus is Perimeter's flagship teacher training experience — a week-long professional development opportunity that brings modern physics to life, often delivered by the very researchers who are making discoveries in the field today.

Techniques pioneered at EinsteinPlus are adapted into teacher's workshops. In 2019/20, Perimeter offered 200 teacher workshops, including several in French, on everything from gravitational waves to black holes, from climate change to quantum.

RESOURCES FOR STUDENTS

To bring modern physics into classrooms across Canada and around the world, Perimeter develops free multimedia classroom resources, each including lesson plans, hands-on activities and demonstrations, guidance for teachers, and original Perimeter videos. Perimeter's educational resources are used across Canada and in 117 other countries around the world.

Material developed in 2019/20 include new resources on black holes and activities for use in classrooms, as well as three new French and six new Portuguese translations of resource kits.

WONDER FOR EVERYONE

Perimeter is recognized as an international leader in public science outreach, striving to increase scientific literacy by sharing the transformative power of physics with curious people everywhere. We hosted six flagship public lectures this past year and produced great science content, from quizzes and games for kids to in-depth feature articles on current research. We work to ensure that scientific ideas reach everyone — from those with a casual interest to those who might make research their life's work.



Perimeter moved quickly to help teachers adapt to online classrooms, providing virtual training for teachers, and module-by-module strategies for adapting Perimeter resources for the virtual classroom. It extended our reach as never before – and teachers across the country voiced their thanks.

“Perimeter’s resources and training have been indispensable to keeping my students learning during the pandemic!”

– Iain Braithwaite, teacher, John F. Ross Collegiate Vocational Institute, Guelph, Ontario





Inspiring Future Women in Science conference, March 2020

CHANGING THE FACES OF PHYSICS

Perimeter is taking concrete actions to increase inclusion, diversity, equity, and accessibility in physics. Here are just a few examples.

EMMY NOETHER INITIATIVES

Supported by the Simons Foundation, our Simons Emmy Noether Fellowships target early- and mid-career women researchers of exceptional promise. Fellows spend periods of up to one year at Perimeter, relieved of teaching and administrative duties and immersed in one of the world's richest research environments.

In another Emmy Noether Initiative, 155 high school students attended our 2020 conference "Inspiring Future Women in Science." Attendees heard from an impressive range of speakers, panellists, and mentors from across sectors, who shared insights on successful careers in science, technology, engineering, and math. The conference was also carried as a live webcast to five Ontario high schools.

INCLUSION, DIVERSITY, EQUITY, AND ACCESSIBILITY

The Inclusive PI Platform is a grassroots initiative made up of more than 50 Perimeter researchers, staff, and students. The Platform aims to make Perimeter a place where people who have historically been excluded from physics – particularly women and racialized people – will be welcomed and empowered.

PHYSICS IN THE FIRST NATIONS AND FAR NORTH

Perimeter Institute is honoured to be invited into Indigenous communities to participate in professional development for teachers, sharing information and learning more about Indigenous ways of knowing. Since 2016, Perimeter has participated in over 25 teacher training workshops in Indigenous communities, collaborating with more than 450 educators.

"It's a great time to be a physicist. It's always a great time to be a physicist. We plant the seeds of the future."

– Donna Strickland, Nobel Laureate, from her address at the 2020 convocation for Perimeter Scholars International

SUPPORTING PERIMETER: A SHARED VISION

Perimeter receives financial support from the Governments of Canada and Ontario, as well as from many private foundations, corporations, and individuals. Their support has allowed us to become the best in the world at what we do.

We work with our government funders to ensure that their constituents are positioned to take advantage of new discoveries in science and technology — like the quantum revolution happening right now that is transforming the economies of Waterloo Region, Ontario, and all of Canada.

Philanthropists and foundations support the Institute's overall strategy of attracting the world's best talent to work on theoretical physics' hardest problems. They also provide targeted funding for projects that reflect the curiosity-driven research that most ignites their passions. This year, for instance, the Riddell Family Charitable Foundation pledged \$10 million to create the Clay Riddell Centre for Quantum Matter, in honour of the late Canadian entrepreneur's enthusiasm for scientific exploration.

We are grateful for every donation and grant we receive, and even more grateful that our community includes so many creative, passionate people who support our vision of the ways theoretical physics can transform the world.

“I support the Perimeter Institute because I believe the work they are doing will drive ambitious scientific breakthroughs that will literally shape our future.”

— Linda Hasenfratz, CEO, Linamar Corporation

To find out more about how you can support Perimeter and join us on this journey of discovery, visit:

www.perimeterinstitute.ca/ways-give



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

Be Part of ^(the) Σ quation²



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www.perimeterinstitute.ca

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