



2016/17 Annual Report Supplement

Covering the Objectives, Activities, and Finances
for the period of August 1, 2016 to July 31, 2017

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To: The Hon. Navdeep Bains, Canadian Minister of Innovation, Science, and Economic Development
Attn.: The Hon. Kirsty Duncan, Canadian Minister of Science

Contents

Objective 1: Achieve breakthroughs in our understanding of the universe	1
Objective 2: Create the world’s strongest community of theoretical physics researchers.....	3
Objective 3: Attract and develop the next generation of brilliant researchers	4
Objective 4: Attract outstanding visiting scientists	6
Objective 5: Act as Canada’s hub for foundational physics research.....	8
Objective 6: Catalyze and support the creation of centres of excellence	11
Objective 7: Share the transformative power of theoretical physics.....	13
Objective 8: Continue to strengthen Perimeter’s visionary public-private partnership	14
Governance	17
Performance Evaluation Strategy.....	17
Investment Strategy	18
Overview of Financial Statements, Expenditures, and Investment Strategy	18
Objectives for 2016/17.....	20
Appendix: Visiting Fellows.....	21

Objective 1: Achieve breakthroughs in our understanding of the universe

Summary of Achievements

- Advanced fundamental research through 502 high-calibre papers¹
- Since inception, Perimeter researchers have produced more than 4,600 papers appearing in over 170 journals, which have attracted more than 210,000 citations to date, attesting to the importance and long-term impact of PI research²
- Launched the Centre for the Universe at Perimeter Institute, a research cluster dedicated to tackling some of the most important questions in cosmology

Highlights

For detailed descriptions of several research highlights for the past year, refer to **pages 8-17** of the Annual Report. For a list of honours, awards, and major grants received by Perimeter researchers, refer to **pages 18 and 19**. For information on the newly established Centre for the Universe at Perimeter Institute, refer to **page 17**.

Supplementary Information (beyond the Annual Report Contents)

Honours, Awards, and Major Grants

The nine Perimeter-authored papers that were recognized by peer-reviewed journals as “Highlights of 2016” (as noted on **page 19** of the Annual Report) are as follows:

- *Journal of Physics A: Mathematical and Theoretical*
 - “Hexagonal Wilson loops in planar $N=4$ SYM theory at finite coupling,” by Clay Riddell Paul Dirac Chair Pedro Vieira and his co-authors
 - “Quantum conical designs,” by PhD student Matthew Graydon and his co-author
 - “Summoning information in spacetime, or where and when can a qubit be?” by Distinguished Visiting Research Chair Patrick Hayden and his co-author
- *New Journal of Physics*
 - “Decorated tensor network renormalization for lattice gauge theories and spin foam models,” by Faculty member Bianca Dittrich, postdoctoral researcher Sebastian Steinhaus, and PhD student Sebastian Mizera
 - “An operational approach to spacetime symmetries: Lorentz transformations from quantum communication,” by Associate Faculty member Markus Mueller and postdoctoral researcher Philipp Hoehn

¹ This reflects the one-year period from August 1, 2016 to July 31, 2017. Each publication has been counted only once, regardless of how many Perimeter researchers collaborated on it.

² This data comes from the Google Scholar and Spire databases.

- “Precise spacetime positioning for entanglement harvesting,” by Visiting Fellow Eduardo Martin-Martinez and his co-author
- *Classical and Quantum Gravity*
 - “Equation of state effects and one-arm spiral instability in hypermassive neutron stars formed in eccentric neutron star mergers,” by Director’s Fellow William East, Distinguished Visiting Research Chair Frans Pretorius, and their co-author
 - “Sgr A* and general relativity,” by associate postdoctoral researcher Tim Johannsen
- *Journal of Physics: Condensed Matter*
 - “A first theoretical realization of honeycomb topological magnon insulator,” by postdoctoral researcher Solomon Owerre

The major research grants (totalling \$3.5 million, as noted on **page 19** of the Annual Report) awarded to Perimeter scientists include the following:

- Clay Riddell Paul Dirac Chair Pedro Vieira is a Principal Investigator on the Simons Collaboration on the Nonperturbative Bootstrap, which was awarded \$10 million USD. The Perimeter portion is \$480,000 USD.
- Faculty members Robert Spekkens and Lucien Hardy were awarded a grant from the John Templeton Foundation as part of the “Quantum Causal Structures” collaboration, which received \$2.42 million USD. The Perimeter portion is \$445,953.
- Eight Perimeter scientists were awarded Discovery Grants totalling \$2,460,960 (over terms of five years) from the Natural Sciences and Engineering Research Council of Canada, as follows:
 - Gluskin Sheff Freeman Dyson Chair Freddy Cachazo: \$330,000 (\$66,000/year over five years)
 - Deputy Faculty Chair Luis Lehner: \$350,000 (\$70,000/year over five years)
 - Faculty member Bianca Dittrich: \$555,000 (\$87,000/year over five years, plus a Discovery Accelerator Supplement of \$40,000/year over three years)
 - Faculty member Lee Smolin: \$265,960 (\$53,192/year over five years)
 - Faculty member Robert Spekkens: \$280,000 (\$56,000/year over five years)
 - Faculty member Guifre Vidal: \$350,000 (\$70,000/year over five years)
 - Associate Faculty member Raffi Budakian: \$180,000 (\$36,000/year over five years)
 - Research Technologies Group Lead Erik Schnetter: \$150,000 (\$30,000/year over five years)

Additional honours received by Perimeter researchers in 2016/17 include:

- Associate Faculty member Michele Mosca was awarded the 2017 Fr. Norm Choate Lifetime Achievement Award by St. Jerome’s College at the University of Waterloo
- Visiting Fellow Thomas Vidick was appointed as one of the 2017 CIFAR Azrieli Global Scholars by the Canadian Institute for Advanced Research, recognizing exceptional early-career researchers

Objective 2: Create the world's strongest community of theoretical physics researchers

Summary of Achievements

- Appointed Avery Broderick and Savas Dimopoulos as Perimeter Research Chairs, bringing the total to nine
- Obtained a \$500,000 investment from the Delaney Family Foundation to support the Delaney Family John Archibald Wheeler Chair in Theoretical Physics
- Recruited Neal Dalal, Yin-Chen He, Timothy Hsieh, and Beni Yoshida as full-time faculty members, which will bring the total to 24
- Welcomed Ben Webster and Jon Yard as new associate faculty members, and recruited Matilde Marcolli, who will arrive in January 2018, bringing the total to 17

Highlights

For details on the recruitment of Perimeter Research Chairs, faculty, and associate faculty, refer to **pages 20-22** of the Annual Report. **Page 23** includes a profile of new Faculty member Beni Yoshida, and detailed looks at the research of Faculty member Kendrick Smith and Delaney Family John Archibald Wheeler Chair Avery Broderick can be found on **pages 28 and 39**, respectively. For complete faculty and associate faculty bios, refer to **pages 54-61**.

For details about Perimeter's world-class research environment – touching on everything from its iconic facility to its 2017 Employee Recommended Workplace Award – refer to **pages 36 and 37** of the Annual Report.

Supplementary Information (beyond the Annual Report Contents)

Expanding Library Collections

A high-quality in-house library is essential to Perimeter's research and learning communities. In 2016/17, Perimeter continued to expand its library collections, in line with a multi-year strategy to provide resident and visiting researchers with comprehensive research resources. The library added 95 new texts, bringing the total to 5,671 in the print collection (6,276 in all formats), plus electronic subscriptions to more than 120 journals that researchers and students can access on-site and remotely.

Objective 3: Attract and develop the next generation of brilliant researchers

Summary of Achievements

- Welcomed 24 postdoctoral researchers in 2016/17 and recruited 19 more for 2017/18
- Thirteen departing postdoctoral researchers obtained tenure-track faculty positions
- Successfully ran the eighth year of the Perimeter Scholars International (PSI) master's program for 27 students and provided ongoing training for 49 PhD students in residence
- Brought 32 Visiting Graduate Fellows to the Institute for a total of 39 visits
- Delivered four specialized courses to researchers and students from surrounding universities

Highlights

For a description of Perimeter's postdoctoral researcher program, refer to **page 23** of the Annual Report. For a complete list of postdoctoral researchers, refer to **page 61**.

For details about the Perimeter Scholars International (PSI) master's program, the PhD program, and the Visiting Graduate Fellows program – as well as a full listing of the 2016/17 PSI faculty – refer to **pages 24 and 25** of the Annual Report. For a complete list of PhD and PSI students, refer to **page 62**.

Supplementary Information (beyond the Annual Report Contents)

Postdoctoral Researchers

Perimeter received 603 applications for its 2017/18 postdoctoral positions and continues to achieve very high acceptance rates, attesting to the Institute's excellent international reputation.

The majority of departing postdoctoral researchers obtained tenure-track faculty positions and continuing research fellowships at top Canadian and international institutions. For example, Michal Heller was awarded a highly prestigious Sofja Kovalevskaja Award of €1.65 million from the Alexander von Humboldt Foundation, enabling him to build and lead a research group at the Max Planck Institute for Gravitational Physics.

The advanced analytical, problem-solving, and quantitative skills developed in physics can also lead to successful careers in a broad range of fields outside academia, including government, technology, and finance. In 2016/17, for example, Juan Carrasquilla is now a research scientist at D-Wave Systems Inc., a quantum computing company based in Burnaby, British Columbia.

Courses

Perimeter shares the expertise of its resident and visiting scientists through advanced graduate courses and non-credit mini-courses on cutting-edge topics. These courses benefit not only Perimeter's resident researchers, but are also open to students of surrounding universities, thereby enhancing their course offerings. In 2016/17, Perimeter offered four graduate courses, meeting targeted objectives.³

³ The graduate courses were: (1) "Algorithmic Techniques for Scalable Many-Core Computing," taught by Perimeter Research Technologies Group Lead Erik Schnetter (September-December 2016); (2) "Supersymmetric Field Theories for Mathematicians," taught by Kevin Costello, the Kreibil William Rowan Hamilton Chair in Theoretical Physics at Perimeter Institute (September-December 2016); (3) "Statistical Mechanics 2," taught by Perimeter Associate Faculty member Roger Melko (January-March 2017); and (4) "String Theory for Mathematicians," also taught by Costello (April-June 2017).

Objective 4: Attract outstanding visiting scientists

Summary of Achievements

- Appointed six leading scientists as Distinguished Visiting Research Chairs⁴ and renewed seven more,⁵ bringing the total to 54
- Appointed seven accomplished researchers as Visiting Fellows⁶ and renewed three more,⁷ bringing the total to 34
- Welcomed 10 early-career researchers as Emmy Noether Visiting Fellows⁸
- Hosted 406 visiting scientists for a total of 459 visits⁹
- Held 20 conferences and workshops, attended by 867 scientists from around the world
- Presented 308 scientific talks (267 seminars and 41 colloquia)
- Partnered on five joint workshops and conferences held at Perimeter¹⁰ and sponsored an additional 14 off-site workshops and conferences

Highlights

For the latest on Perimeter's Distinguished Visiting Research Chairs (DVRCs) and Visiting Fellows (VFs) programs, refer to **pages 22 and 23** of the Annual Report. The complete listing of DVRCs can be found on **page 21** and the complete listing of VFs is included as an appendix in this document. For details on the

⁴ The new DVRCs are Scott Aaronson (University of Texas at Austin), Itzhak Bars (University of Southern California), Charles Bennett (IBM Thomas J. Watson Research Center), John Cardy (University of California, Berkeley, and University of Oxford), John March-Russell (University of Oxford), and Xiao-Gang Wen (Massachusetts Institute of Technology).

⁵ Matthew Fisher, Ted Jacobson, Dam Son, Andrew Strominger, Raman Sundrum, and Zhenghan Wan renewed their terms through 2019, while Barbara Terhal renewed hers through 2020.

⁶ The new Visiting Fellows are Joseph Ben Geloun (University of Paris 13), Simon Caron-Huot (McGill University), David Curtin (University of Maryland, College Park), Daniel Halpern-Leistner (Cornell University), Gilbert Holder (University of Illinois at Urbana-Champaign), Matthew Leifer (Chapman University), and Markus Mueller (Institute for Quantum Optics and Quantum Information).

⁷ Fernando Brandao, Giulio Chiribella, and Razvan Gurau renewed their terms through 2019.

⁸ The Emmy Noether Visiting Fellows who spent time at Perimeter in 2016/17 were Celine Boehm (Durham University), Radja Boughezal (Argonne National Laboratory), Gemma De las Cuevas (University of Innsbruck), Astrid Eichhorn (Heidelberg University), Natalia Perkins (University of Minnesota), Katarzyna Rejzner (University of York), Mairi Sakellariadou (King's College London), Didina Serban (Institute of Theoretical Physics/CEA-Saclay), Sumati Surya (Raman Research Institute), and Bei Zeng (University of Guelph).

⁹ This included a strategic mix of affiliates, collaborators, potential recruits, and seminar and colloquia speakers, as well as 17 Distinguished Visiting Research Chairs and 10 Visiting Fellows.

¹⁰ These included: (1) "Exact Operator Algebras in Superconformal Field Theories," with the Simons Foundation; (2) "Hitchin Systems in Mathematics and Physics," with the Templeton Foundation; (3) "Radiative Corrections at the Intensity Frontier of Particle Physics," with TRIUMF; and (4) "Contextuality, Conceptual Issues, Operational Signatures, and Applications" and (5) "Women in Physics Canada 2017," both with the Institute for Quantum Computing at the University of Waterloo.

Emmy Noether Visiting Fellows (ENVs), including their context in Perimeter's broader Emmy Noether Initiatives, as well as a profile on ENVF Kasia Rejzner, refer to **pages 40 and 41** of the Annual Report.

For information on Perimeter's visitor program, refer to **page 28** of the Annual Report. **Pages 63-66** also include a complete listing of the Institute's scientific visitors for the year.

For updates on Perimeter's scientific events – conferences, workshops, seminars, and colloquia – as well as information about Perimeter's online archive of talks, refer to **pages 26 and 27** of the Annual Report. For a complete list of conferences, workshops, and academic sponsorships, refer to **pages 67 and 68**.

Objective 5: Act as Canada’s hub for foundational physics research

Summary of Achievements

- Appointed eight new Affiliates from across the country and renewed 15 more, giving the Institute 120 Affiliates in total
- Signed a new partnership agreement with the Institute for Quantum Optics and Quantum Information of the Austrian Academy of Sciences, and strengthened existing ties to leading centres such as TRIUMF and SNOLAB
- Deepened ties with experimental and observational centres in Canada and abroad
- Continued to work closely with all relevant partners to foster the Quantum Valley ecosystem
- Released the Waterloo Global Science Initiative (WGSi) *OpenAccess Energy Blueprint* and completed impact activities tied to the OpenAccess Energy Summit
- Jointly appointed three associate faculty members with the University of Toronto and the University of Waterloo (see Objective 2)
- Partnered with the University of Waterloo to hold the PSI master’s program and involved faculty from Canadian universities as lecturers¹¹ (see Objective 3)
- Hosted five joint workshops and conferences with national and international partners, and sponsored an additional 14 (see Objective 4)

Highlights

For information on Perimeter’s Affiliates, collaborations, and partnerships – including a sidebar on Faculty member Kendrick Smith’s work with the Canadian Hydrogen Intensity Mapping Experiment (CHIME) in British Columbia – refer to **pages 28 and 29** of the Annual Report. For a complete listing of the Institute’s Affiliates, refer to **pages 66 and 67**.

Supplementary Information (beyond the Annual Report Contents)

Catalyst for Quantum Valley

In 2016/17, Perimeter continued to work closely with experimentalists at the Institute for Quantum Computing (IQC) at the University of Waterloo and other key players in Waterloo Region¹² to ensure

¹¹ Lecturers included: Richard Cleve, Institute for Quantum Computing at the University of Waterloo; Debbie Leung, IQC/University of Waterloo; Frank Marsiglio, University of Alberta; Eduardo Martin-Martinez, IQC/University of Waterloo; Kevin Resch, IQC/University of Waterloo; and Sean Tulin, York University.

¹² This includes the surrounding academic community (including the Quantum-Nano Centre and the Waterloo Institute of Nanotechnology, both at the University of Waterloo), the region’s vibrant start-up community (including Communitech and Universal Quantum Devices), and venture capitalists (such as Quantum Valley Investments, Mike Lazaridis’ latest venture).

Canada remains at the forefront of international efforts to create new quantum industries, which will in turn spark major job and value creation.

The field of quantum condensed matter is crucial to the development of quantum technologies. This presents a significant strategic opportunity for Perimeter to build on existing strengths. This year, the Institute recruited a number of quantum and condensed matter specialists, as part of its new Quantum Matter Initiative. New Faculty members Yin-Chen He, Timothy Hsieh, and Beni Yoshida were the most visible new recruits in these areas, but many additional recruitment successes include Associate Faculty member Jon Yard; Distinguished Visiting Research Chairs Scott Aaronson, Charles Bennett, and John Cardy; Emmy Noether Visiting Fellows Gemma De Las Cuevas, Natalia Perkins, and Bei Zeng; and numerous postdoctoral researchers.

Engagement with Experimental and Observational Centres

Experiment is the ultimate test of all theory. Recognizing this, Perimeter helped to catalyze the creation of IQC in 2002, and it continues to be Perimeter's closest experimental partner today. IQC is led by Interim Director Kevin Resch, a Perimeter Affiliate, and Deputy Director David Cory, an associate faculty member at Perimeter. Many more Perimeter researchers are cross-appointed at IQC.¹³

In 2016/17, Perimeter continued to strengthen ties to experimental and observational centres around the world, most notably through the establishment of the Centre for the Universe (CFU) at Perimeter Institute. The CFU will deepen existing ties with the Square Kilometre Array (SKA), the Laser Interferometer Gravitational-Wave Observatory (LIGO), the Event Horizon Telescope (EHT), SNOLAB (the next generation of the Sudbury Neutrino Observatory), and CHIME.

Examples abound of the progress that can happen when theorists and experimentalists work together. In the last year alone, among many other examples, Perimeter Faculty member Kendrick Smith developed novel methods to detect fast radio bursts by analyzing the data produced by CHIME in real time; Delaney Family John Archibald Wheeler Chair Avery Broderick and then-associate postdoctoral researcher Tim Johannsen tested general relativity using a trove of observational data from the EHT; and Stavros Niarchos Aristarchus Chair Asimina Arvanitaki has proposed ways to repurpose gravitational wave detectors to search for dark matter.

Such exciting collaborations are only expected to grow, as Perimeter scientists continue to connect with major experimental efforts worldwide. The Institute's many ties include the following:

- The Institute has formal partnership agreements with SNOLAB, an underground science laboratory specializing in neutrino and dark matter physics, and TRIUMF, Canada's particle accelerator centre.

¹³ Associate Faculty members Raymond Laflamme and Michele Mosca were founding members of IQC and continue to be jointly appointed there, as are Associate Faculty members Raffi Budakian and Jon Yard, and postdoctoral researcher Dave Touchette. Senior Research Affiliate Steve MacLean and Emmy Noether Visiting Fellow Bei Zeng are associates at IQC, and the institutes share a number of affiliates and students as well.

- Avery Broderick is a member of the EHT, which is working to directly observe the immediate environment of a black hole for the first time. He is also one of several Perimeter researchers associated with the Institute’s EHT Initiative, which is building a team of faculty members, postdoctoral researchers, and graduate students to conduct leading-edge analysis of astrophysical data collected by the EHT. Deputy Faculty Chair Luis Lehner and Faculty member Guifre Vidal are also involved.
- Kendrick Smith works on a number of experimental collaborations aimed at measuring the cosmic microwave background (CMB), including CHIME, the Planck satellite, and the Hyper-Suprime Cam (HSC) at the Subaru telescope.
- Asimina Arvanitaki is part of the ARIADNE collaboration (Axion Resonant InterAction DetectioN Experiment), which is looking for axion mediated interactions in matter. She has also proposed a number of experimental tests of fundamental physics using optically levitated sensors, atomic clocks, and nuclear magnetic resonance.
- Associate Faculty member Maxim Pospelov is an associate member of the BaBar collaboration, which studies the physics of b-quarks and other intermediate mass particles. He is also part of the Global Network of Magnetometers for Exotic (GNOME) experiment, and directly collaborates with experimental physicists at TRIUMF and Fermilab.

Lastly, Perimeter connects with experiment through its conference program, and several conferences in 2016/17 revolved directly around experimental findings and challenges.¹⁴ One notable example was the fifth edition of the Tri-Institute Summer School on Elementary Particles (TRISEP) – a partnership between Perimeter, SNOLAB, and TRIUMF – which took place in July 2017 at SNOLAB; Perimeter’s Asimina Arvanitaki was one of the lecturers.

Waterloo Global Science Initiative

The Waterloo Global Science Initiative (WGSi) is an independently funded, non-profit partnership between Perimeter Institute and the University of Waterloo to promote dialogue and develop solutions to complex global issues.

In March 2017, WGSi released the *OpenAccess Energy Blueprint*, which detailed recommendations and implementation ideas arising from WGSi’s third summit, held in April 2016. The *Blueprint* charts a course toward a future with universal electricity access, based on the recommendations of senior researchers, PhD students, community activists, and entrepreneurs representing diverse interests from 24 countries and five First Nations communities. Through a series of partnerships and events, WGSi distributed the *Blueprint* and completed other impact activities tied to the 2016 Summit.

¹⁴ These included “Experimental Quantum Foundations” (September 23, 2016), “International Workshop on Quantum Spin Ice” (June 7-9, 2017), “Radiative Corrections at the Intensity Frontier of Particle Physics” (June 12-14, 2017), “New Directions in Dark Matter and Neutrino Physics” (July 20-22, 2017), and “Contextuality: Conceptual Issues, Operational Signatures, and Applications” (July 24-28, 2017).

Objective 6: Catalyze and support the creation of centres of excellence

Summary of Achievements

- Provided continued expertise in support of both the African Institute for Mathematical Sciences – Next Einstein Initiative (AIMS-NEI) and the South American Institute for Fundamental Research (SAIFR)
- Renewed the agreement for the Fields-Perimeter Institute Africa Postdoctoral Fellowship, formally bringing AIMS-NEI into the partnership
- Shared Perimeter’s expertise in educational outreach more broadly, engaging partners including the European Organization for Nuclear Research (CERN), the Laser Interferometer Gravitational-Wave Observatory (LIGO), and the Brainport technology region in the Netherlands

Highlights

For information on Perimeter’s global outreach efforts, including the renewed Fields-Perimeter Institute Africa Postdoctoral Fellowship, refer to **pages 28 and 29** of the Annual Report.

Supplementary Information (beyond the Annual Report Contents)

AIMS-NEI

Founded by Perimeter Director Neil Turok, AIMS-NEI seeks to create a pan-African network of centres providing advanced mathematical and scientific education to exceptional African graduates. Since 2003, the AIMS network has grown from a single centre in South Africa to a network of six across the continent, producing more than 1,200 graduates.

In 2016/17, Perimeter continued to leverage the expertise of both its research and administrative staff to assist the AIMS-NEI network.

- Perimeter postdoctoral researcher Prince Osei moved to Rwanda to become the Project Developer of Quantum Leap Africa, a brand new information science and quantum technology hub created by AIMS.
- Perimeter staff helped with preparations for the opening of the sixth AIMS centre, AIMS-Rwanda, in August 2016.
- Perimeter researchers continue to be involved in teaching at AIMS centres.

SAIFR

In 2015, the International Centre for Theoretical Physics – South American Institute for Fundamental Research (ICTP-SAIFR), an emerging centre of excellence in theoretical physics located at São Paulo State

University (UNESP) in Brazil, became Perimeter's second major global outreach partner. SAIFR has many commonalities with Perimeter, including a number of research areas, as well as active visitor and conference programs.

In 2016/17, Perimeter continued to leverage the expertise of its research and administrative staff to assist with the nascent ICTP-SAIFR's growth.

- In November 2016, the partnership was formally celebrated in São Paulo with a ceremony involving the Canadian Ambassador to Brazil.
- Pedro Vieira, the Clay Riddell Paul Dirac Chair in Theoretical Physics at Perimeter Institute, continues to spend up to six months per year in Brazil, helping to develop SAIFR, while Deputy Faculty Chair Luis Lehner serves on SAIFR's Scientific Council.
- More than a dozen Perimeter researchers, students, and educational outreach staff spent time at SAIFR, including Faculty Chair Robert Myers, Stavros Niarchos Aristarchus Chair Asimina Arvanitaki, and Director of Educational Outreach Greg Dick.

Objective 7: Share the transformative power of theoretical physics

Summary of Achievements

- Facilitated nearly 10 million student interactions through educational programs and resources, bringing the total to 30 million to date
- Reached more than 100,000 Canadians in more than 180 communities through Innovation150, a Perimeter-led signature initiative of the country's sesquicentennial celebrations
- Hosted the 15th International Summer School for Young Physicists (ISSYP) and gave 11 Physica Phantastica presentations – reaching nearly 1,000 students across Canada
- Delivered 123 workshops to over 3,700 educators across Canada and abroad, ultimately translating to more than 275,000 student interactions with Perimeter resources
- Hosted the “Inspiring Future Women in Science” conference for nearly 200 Canadian high school students
- Presented eight engaging public lectures to capacity audiences on-site and a growing global audience via webcasts and media partnerships
- Launched insidetheperimeter.ca, an online publishing platform, and increased Perimeter's digital media communications, with over 175,000 page views and 875,000 YouTube video views, as well as strong growth across the Institute's social media channels

Highlights

For information on Perimeter's educational outreach efforts, refer to **pages 30-35** of the Annual Report. This includes details about the Institute's International Summer School for Young Physicists, EinsteinPlus Teachers' Camp, “Inspiring Future Women in Science” conference, Public Lecture Series, cultural events, digital and social media outreach, media coverage, and year-long Innovation150 celebrations.

Objective 8: Continue to strengthen Perimeter’s visionary public-private partnership

Summary of Achievements

- Finalized new five-year, \$50 million funding agreements with both the Province of Ontario and the Government of Canada
- Reached a major \$25 million private fundraising milestone set in 2014 with several large gifts this year as follows:
 - An anonymous founding donation of \$5 million to launch the Centre for the Universe at Perimeter Institute
 - \$1 million from Cenovus Energy in support of the Distinguished Visiting Research Chairs program
 - \$500,000 from the Delaney Family Foundation to support the Delaney Family John Archibald Wheeler Chair, held by Avery Broderick

Highlights

For details about Perimeter’s public-private partnership, including major successes in 2016/17, refer to **pages 38-41** of the Annual Report. This includes the complete membership listing of the Perimeter Institute Leadership Council and Emmy Noether Council, as well as details about the Institute’s Emmy Noether Initiatives. It also includes profiles of Emmy Noether Visiting Fellow Kasia Rejzner and Avery Broderick, the newly appointed Delaney Family John Archibald Wheeler Chair, funded by a \$500,000 investment from the Delaney Family Foundation. For information on the Centre for the Universe at Perimeter Institute, launched with an anonymous \$5 million founding donation, refer to **page 17**. For a full list of public and private supporters, refer to **pages 42 and 43**.

Supplementary Information (beyond the Annual Report Contents)

Public Partners

Perimeter Institute is funded through an innovative public-private partnership, which shares the opportunities and benefits of long-term investment in fundamental research. Perimeter’s public partners understand that ongoing, strategic investment in foundational theoretical physics positions Canada and Ontario for success in an extremely cost-effective field with an unmatched record of advancing human knowledge and seeding innovation. As recent independent reviews and audits demonstrate, Perimeter is already providing excellent return on investment.¹⁵

¹⁵ For example, in October 2015, Perimeter’s Scientific Advisory Committee concluded, “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

In 2016/17, Perimeter continued to responsibly steward all public investments using best practices in financial management and to fulfill all reporting requirements. The Institute worked with public partners to position Canada at the forefront of foundational physics during one of the most exciting times in the field's history. Highlights of these activities included the following:

- Led a partnership with four other Canadian outreach organizations to deliver Innovation150, a signature initiative of Canada's sesquicentennial celebrations, having been selected for the honour by the Department of Canadian Heritage
- Partnered with several Canadian universities and research institutions as part of the Canadian Particle Astrophysics Research Centre, being created at Queen's University with an investment of \$63.7 million from the Government of Canada
- Welcomed senior government officials, private sector leaders, and members of the media from 27 countries as part of the sixth Americas Competitiveness Exchange, for a tour of the Institute, a keynote address from Perimeter Founder and Board Chair Mike Lazaridis, and a panel discussion on how investments and partnerships in science can advance society
- Served as a "Nominating Partner" for the Governor General's Innovation Awards
- Provided briefings to leaders across ministries, agencies, and levels of government

Private Partners

Private partners who share and invest in Perimeter's vision are crucial to the Institute's ability to realize its ambitious goal of long-term global leadership in theoretical physics research, training, and outreach. The Institute's Advancement efforts focus largely on individual philanthropists, corporations, and foundations whose missions align with Perimeter's – whether they share the Institute's spirit of innovation and discovery, its belief in the transformative power of physics, or its conviction that Canada can be a world-leader in fundamental research.

Beyond what is outlined in the Annual Report, highlights of the past year include the following:

- "Friends of Perimeter Institute" launched in the US as a public charity, opening opportunities for significant growth in the Institute's international fundraising mandate.
- Perimeter's Leadership Council – a group of prominent volunteers who act as ambassadors for the Institute in the business and philanthropic communities – welcomed Jennifer Scully-Lerner, Vice President, Goldman Sachs.
- The Emmy Noether Council – a group of volunteers who provide expertise, donations, and other support to help bring more women into physics – welcomed two new members: Lisa Lyons Johnston, President of Kids Can Press at Corus Entertainment Inc., and Susan Brown, Senior Vice President of the Alberta and Northwest Territories Region for BMO Financial Group. The Council

invested in it as does the Perimeter Institute." In January 2016, an independent audit by KPMG concluded, "Perimeter has successfully positioned Canada as a world leader in theoretical physics research."

was also pleased to have Sherry Shannon-Vanstone, President and CEO of Trustpoint Innovation Technologies Ltd., move into the Council Co-Chair role.

- The Institute held several successful events in the last year, increasing awareness of its mission in the Greater Toronto Area with events in the MaRS Discovery District and at the TIFF Bell Lightbox, and across the country via the Innovation150 tour. Perimeter now has networks of donors in a number of key Canadian centres, as well as in New York City and Silicon Valley.

Governance

For Perimeter's governance structure, including complete bios for all members of the Board of Directors and the Scientific Advisory Committee, refer to **pages 44-47** of the Annual Report.

Performance Evaluation Strategy

Scientific

Perimeter Institute utilizes an array of performance monitoring and evaluation policies, systems, and processes (both internal and external) that are re-evaluated and updated on a regular basis. These mechanisms to measure outcomes, results, and impact include:

Performance Monitoring – Internal

- Annual reports on research activity submitted to the Institute's Director by all faculty and associate faculty members for evaluation
- Annual performance reviews of all staff
- Ongoing monitoring of publication and citation records
- Post-conference reports and evaluation
- Visitor research activity reports and ongoing tracking of all output
- Regular updates and monitoring of progress of all scientific programs
- Mid-term researcher performance reviews
- Postdoctoral researcher mentorship program
- Monitoring of postdoctoral researchers' post-Perimeter placement success
- Monitoring of researchers' international presence and impact through collaborations and invitations to lecture
- Internal review and evaluation of all outreach programs and products

Performance Monitoring – External

- Regular reporting to international Scientific Advisory Committee with subsequent performance assessment and recommendations
- Review of tenured faculty hires and promotions by Scientific Advisory Committee
- Peer review of publications
- Annual audit of financial statements by an independent auditor
- Other performance audits and reviews in accordance with grant agreements
- External review and evaluation of all outreach programs and products

Investment Strategy

Public-Private Partnership

Perimeter Institute exists through a cooperative and highly successful public-private approach to investment that provides for ongoing operations while, at the same time, safeguarding future opportunities.

Public partners contribute to research, training, and outreach activities and, in keeping with individual grant requirements, receive ongoing updates, reports, and yearly audited financial statements as required to ensure value for money while remaining aware of the Institute's research productivity and outreach impact.

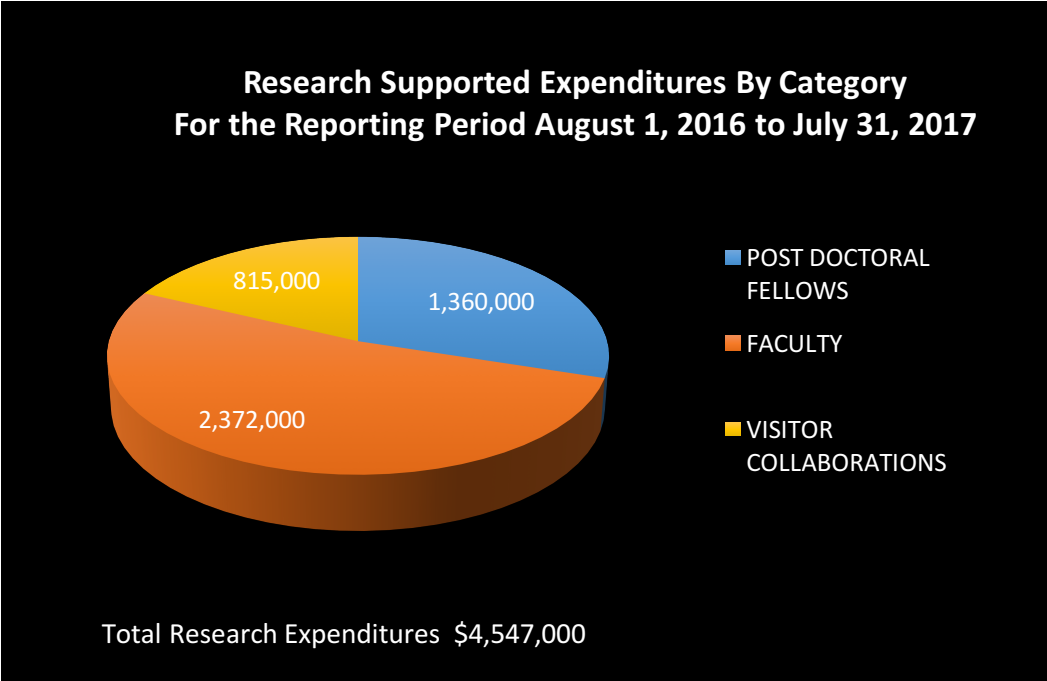
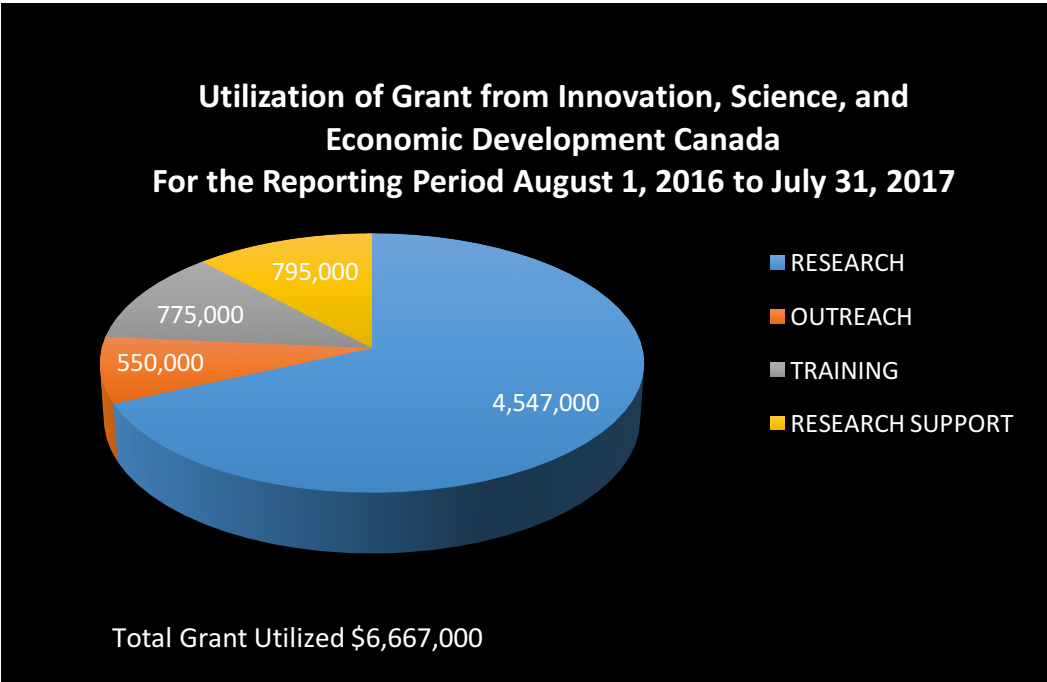
Private funds from a continuously growing donor base are used, in part, to fund operations, while a portion is protected in an endowment that is primarily designed to receive and increase donated monies by maximizing growth and minimizing risk in order to contribute to the strongest possible long-term financial health of the Institute.

Perimeter Institute continues to be an innovative example of a public-private partnership, uniting government and philanthropists in a common quest to secure the transformative potential of scientific research in Canada.

Overview of Financial Statements, Expenditures, and Investment Strategy

For Perimeter's summary of operating costs and details about its income, financial position, and long-term plan, refer to **pages 48 and 49** of the Annual Report. For the Institute's audited financial statements and the report of the auditor on the audited financial statements, refer to **pages 50-52**.

Expenditure of Innovation, Science, and Economic Development Canada Grant



Objectives for 2016/17

For a statement of Perimeter's objectives for the coming year, refer to **page 53** of the Annual Report.

Appendix: Visiting Fellows

Jonathan Barrett, University of Oxford
Joseph Ben Geloun, University of Paris 13
Eugenio Bianchi, Pennsylvania State University
Fernando Brandão, California Institute of Technology
Vitor Cardoso, Instituto Superior Técnico
Simon Caron-Huot, McGill University
Giulio Chiribella, University of Oxford
Philippe Corboz, University of Amsterdam
David Curtin, University of Maryland, College Park
Neal Dalal, University of Illinois at Urbana-Champaign
Fay Dowker, Imperial College London
Sergei Dubovsky, New York University
Maite Dupuis, University of Waterloo
Tobias Fritz, Max Planck Institute for Mathematics in the Sciences
Jerome Gauntlett, Imperial College London
Ruth Gregory, Durham University
Razvan Gurau, École Polytechnique
Jutho Haegeman, Ghent University
Daniel Halpern-Leistner, Cornell University
Gilbert Holder, University of Illinois at Urbana-Champaign
Zohar Komargodski, Weizmann Institute of Science
John Laiho, Syracuse University
Christopher Laumann, Boston University
Matthew Leifer, Chapman University
Si Li, Tsinghua University
Etera Livine, École Normale Supérieure de Lyon
Markus Mueller, Institute for Quantum Optics and Quantum Information
Alejandro Perez, Aix-Marseille University
Rachel Rosen, Columbia University
Sarah Shandera, Pennsylvania State University
Kris Sigurdson, University of British Columbia
Brian Swingle, University of Maryland, College Park
Thomas Vidick, California Institute of Technology
Neal Weiner, New York University