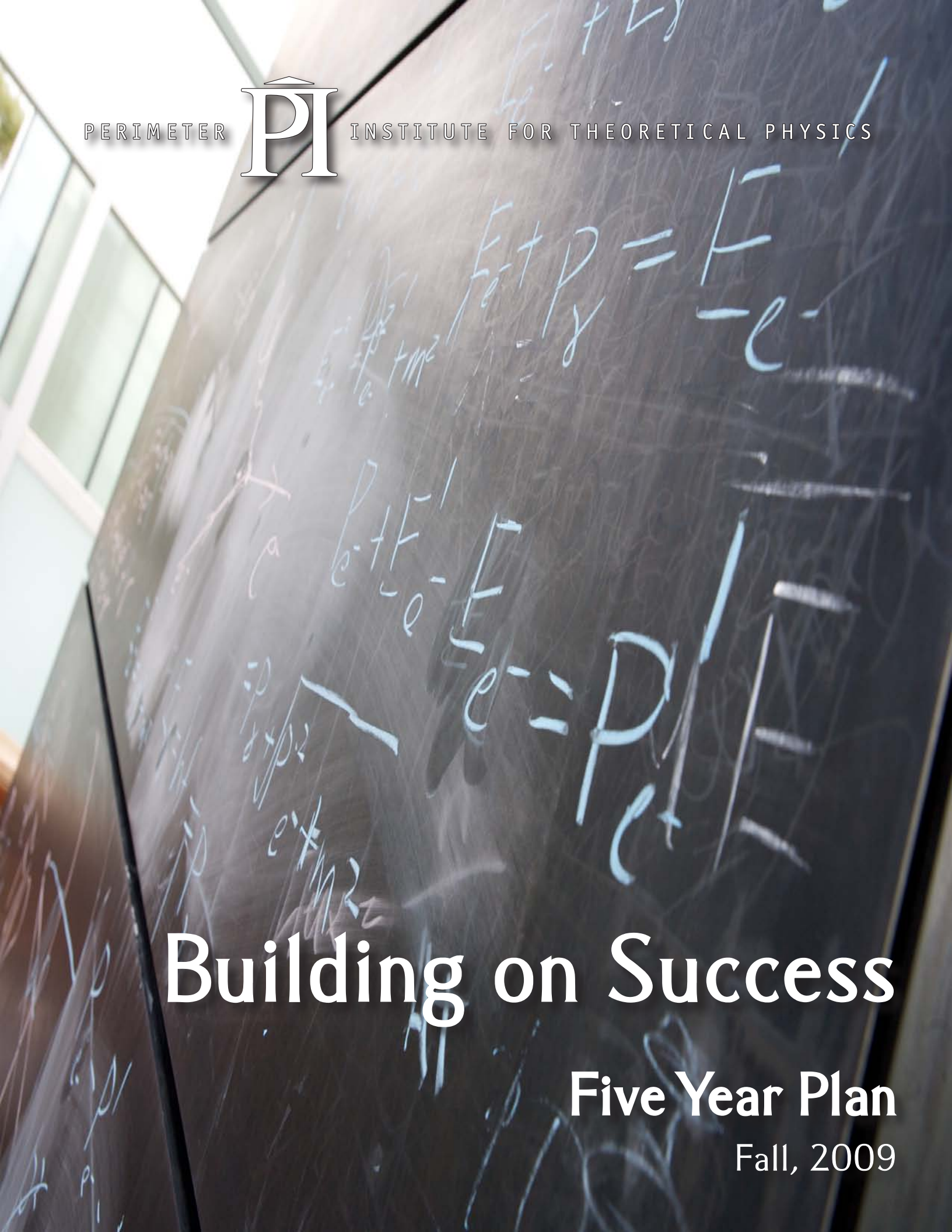
PERIMETER INSTITUTE FOR THEORETICAL PHYSICS



Building on Success

Five Year Plan

Fall, 2009

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Mission Statement

Perimeter Institute for Theoretical Physics is an independent, resident-based research institute devoted to foundational issues in theoretical physics at the highest levels of international excellence. We strive to create a lively and dynamic research atmosphere where many approaches to fundamental questions, both orthodox and unorthodox, are pursued simultaneously and where a balance between formal and phenomenologically-oriented research is established. We are determined to collaborate constructively with the surrounding academic community, in particular by creating outstanding educational and research opportunities for graduate students. We are equally determined to create a world-class outreach program which conveys the wonder and mystery of the universe and the importance of future scientific breakthroughs to the general public in Canada and beyond.

Building on Success

Executive Summary

Theoretical physics is one of the highest impact, yet lowest cost, fields in science. Its breakthroughs—such as those due to Newton, Maxwell and Einstein—enabled the creation of new technologies which have literally transformed society. Today, its ideas drive and guide giant international experiments like the Large Hadron Collider, which push technology to its limits and inspire the public about science. Theoretical physics is highly interdisciplinary, contributing key concepts to diverse fields from astronomy to neuroscience, pure mathematics to computer science. It is above all a creative field constantly reinventing itself, discovering deeper insights into nature while broadening its range of application.

Recognizing theoretical physics' fundamental significance and exceptional cost-effectiveness, Perimeter Institute was founded ten years ago in an audacious initiative to vault Canada to a leading position at this frontier of modern science and brand the nation as a world leader in basic research. PI's twin focus on quantum theory and gravity placed it at the apex of 21st century theoretical physics. The Institute's outstanding design and challenging mission have succeeded in attracting talented young researchers and an excellent faculty, rapidly winning PI a global reputation.

PI now intends to build on this promising start with the goal of becoming one of the world's leading centres for foundational theoretical physics. It seeks to act as a global resource for the field, promoting research excellence and stimulating major scientific breakthroughs. PI has already created an exceptional research environment and culture, promoting innovation, cross-fertilization and the emergence of youthful talent. It is now in a position to assemble a unique research community drawing on the combined insights of world-leading theorists working in a range of complementary disciplines, to explore the most difficult and important problems in the field.

Over the next 5 years, Perimeter Institute intends to:

- Create the world's best environment for theoretical physics research with the addition of the *Stephen Hawking Centre at PI*, a 55,000 square foot expansion of the existing facility in Waterloo.

- Broaden its team of researchers to cover the full spectrum of physics: from subatomic, to condensed matter, to cosmology, and complex systems, bringing together the experience and insights from these fields while retaining PI's focus on quantum theory and spacetime, and their unification.

- Continue to recruit Faculty members of the highest international calibre to build its community of outstanding scientists to critical mass, including a number for whom highly prestigious Research Chairs will be created.

- Recruit the most promising Postdoctoral Researchers, continuing to build the world's largest group of ambitious, independent minded, young theoretical physicists.

- In collaboration with university partners, further its commitment to researcher training by attracting outstanding graduate students and preparing them for cutting edge research.

- Fully establish the Distinguished Research Chairs program, making PI a “second research home” to 30 of the world’s leading theoretical physicists.

- Engage with scientists at experimental and observational centres such as the Large Hadron Collider; the Planck satellite; VISTA, VLT, the SKA and other observatories; SNOlab and other astroparticle facilities; and LIGO, LISA and other gravitational wave detectors.

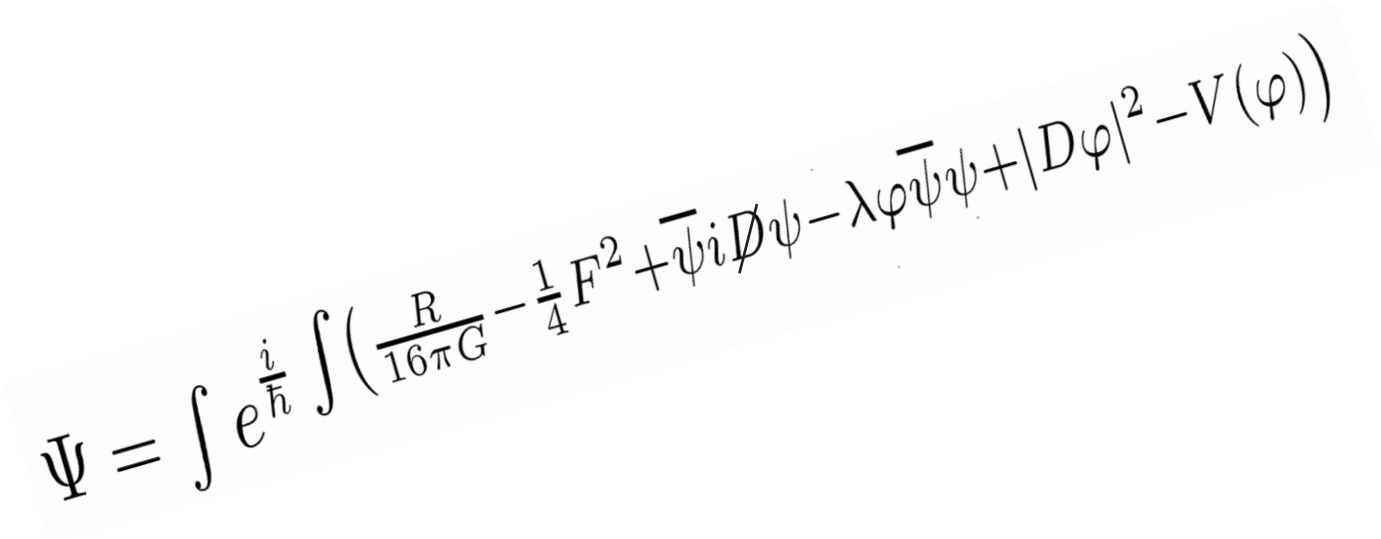
- Host timely, focused conferences, workshops, seminars and courses. PI will choose topics of workshops and conferences strategically, by identifying new areas of exceptional promise where a conference, workshop, seminar or school is likely to have a significant outcome.

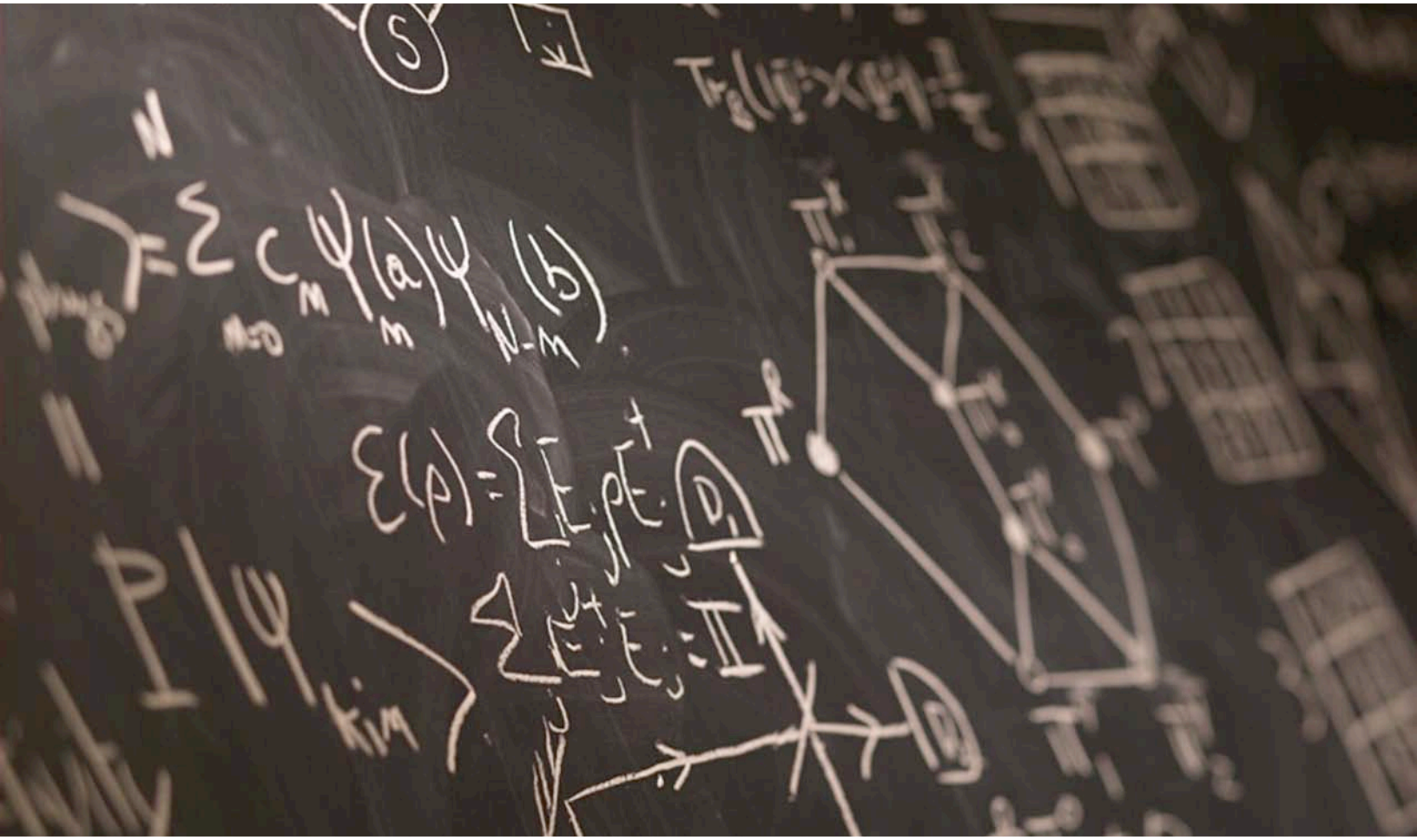
- Increase its role as Canada’s focal point for foundational physics research.

- Develop collaboration agreements and partnerships to encourage scientific exchange visits, collaborations and joint activities with leading centres throughout the world in order to promote progress in research areas of common interest.

- Support the emergence of innovative centres of excellence promoting high level math and physics across the developing world, where a vast pool of talent lies waiting to be unlocked.

- Continue to build its highly regarded outreach program, focusing on growing the awareness of the importance of basic research and the power of theoretical physics; identifying and nurturing the most promising young scientists and encouraging them to pursue scientific careers; and engaging in global outreach initiatives by exporting its products and programs to targeted areas internationally.





Achieving major research breakthroughs

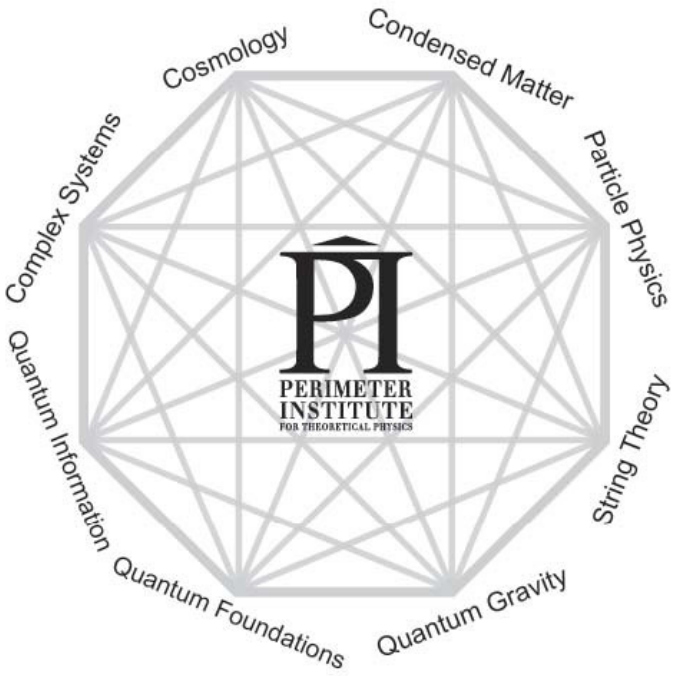
The research programs at PI are focused on the greatest challenges facing fundamental theoretical physics in the 21st century, namely, discovering a deeper understanding of the quantum laws of physics and the spacetime arena in which they operate. This mission is founded on the pillars of twentieth century physics, namely quantum theory, describing the behavior of matter and energy at atomic and subatomic scales, and general relativity, describing gravity, stars, galaxies and the universe itself. Both theories match a huge range of observations to extraordinary accuracy. However, one of the greatest unsolved problems in theoretical physics, and a key objective of PI, is to find a consistent framework which unifies the two theories. This question is central to resolving key puzzles about the physical universe, from understanding the dark energy which shapes its cosmological evolution to determining the essential nature of matter and forces on subatomic scales.

While retaining its inspiring twin focus on quantum theory and spacetime, PI will broaden its range of research to combine complementary insights gained from physics on all length scales: from subatomic, to mesoscopic condensed matter systems, to cosmology, and to complex systems in which many time and length scales are involved.

Eight fields have been carefully chosen to take PI towards critical mass, incorporating expertise over the full spectrum of physics. It should be understood that this list is not intended to be exclusive. There are other complementary disciplines, especially at the intersections of these fields, that PI may choose to develop.

Taken together, these fields will form a whole far greater than the sum of its parts. Perimeter Institute will operate as a single interdisciplinary research community which uses complementary insights from each of these fields to promote progress in all of them. More often than not, cutting edge research involves several fields. The fundamental unity of theoretical physics is a huge source of research strength, which PI draws upon and, indeed, is coming to epitomize.

PI's strategically chosen combination of research directions is unique worldwide. The multidisciplinary approach instills a collaborative atmosphere which maximizes cross-fertilization of ideas and increases the probability of breakthroughs.



A single interdisciplinary community with complementary fields of research forming a whole far greater than the sum of its parts.

Becoming the research home of a critical mass of the world's leading theoretical physicists

A priority for Perimeter Institute in the coming years is to continue to recruit Faculty members of the highest international calibre to build its community of outstanding scientists to critical mass. PI's dynamic environment with research freedom and collaboration opportunities second to none will continue to position it as a highly attractive destination. With ever expanding seminar, visitor, training, conference and workshop programs, PI will offer its researchers more opportunities and resources to interact scientifically with other experts and surround themselves with the brightest young minds in the field. In short, PI will offer greater opportunities for its scientists to maximize their research productivity.

A select number of prestigious Research Chairs will be created, offering highly attractive opportunities to leading senior scientists.

Recruitment of women Faculty and those from diverse national and cultural backgrounds will be actively prioritized: PI wishes to take the lead in these respects, in order to encourage new talent into the field. Candidates with interdisciplinary expertise who will act as the "glue" encouraging connections in the PI research community will also be a high priority.

The Associate Faculty program will continue to present an excellent opportunity for PI to integrate with and support the Canadian academic community, fostering cooperation allowing for joint recruitment of outstanding researchers, and enhancing the capacity of and national reputation for fundamental physics research.

PI's eventual steady state recruitment goal is approximately 25 Faculty members (11 at present) and 25 Associate Faculty members (11 at present).

Generating a flow-through of the most promising talent

Perimeter Institute has long recognized that the life blood of theoretical physics is brilliant young people. The next 5 years will see PI further its commitment to researcher training by attracting ambitious young scientists and providing them with potent and widely applicable skills.

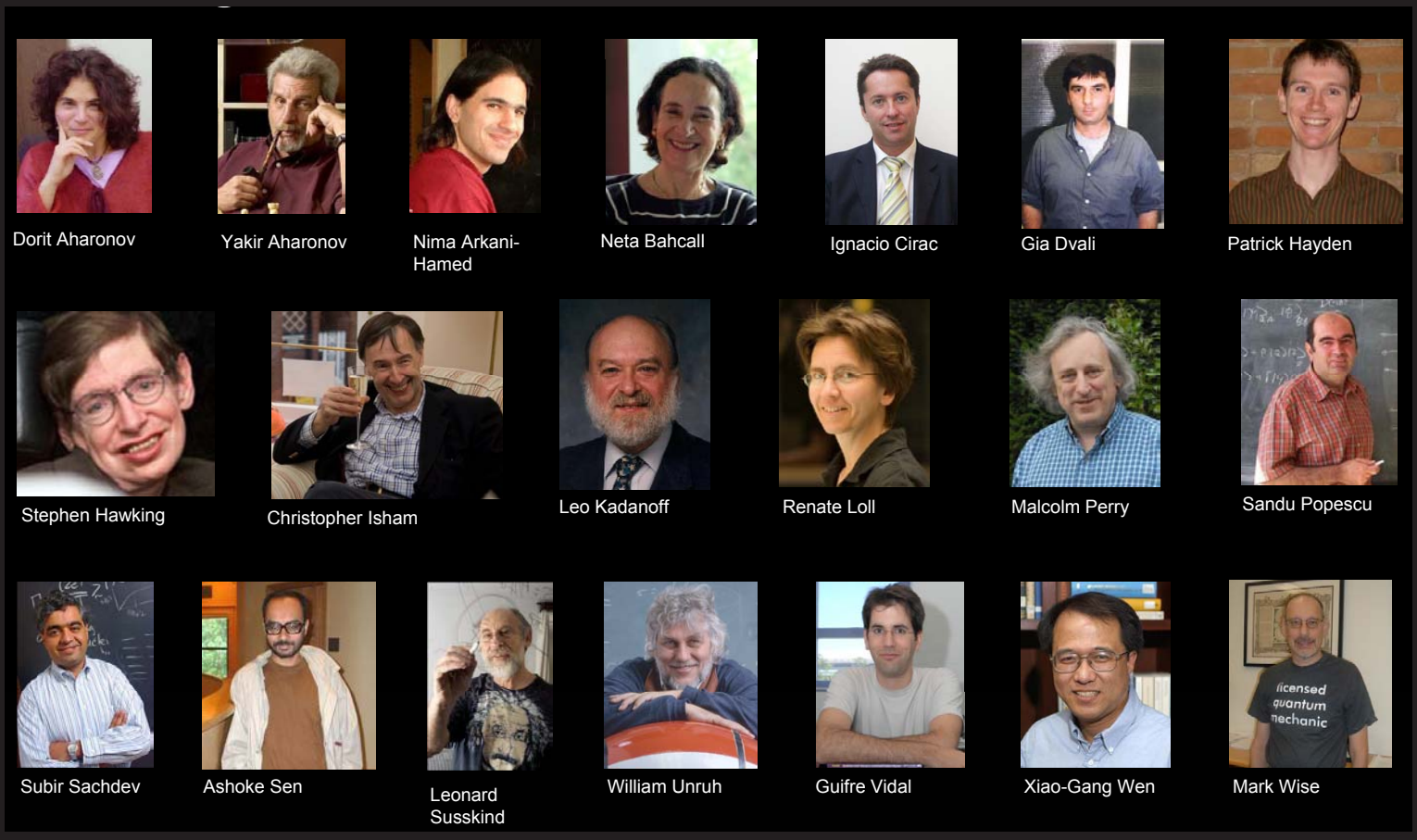
PI aims to recruit the world's most promising Postdoctoral Researchers, seeking out independent-minded individuals and encouraging them to pursue unorthodox, "riskier" research. PI postdocs are also encouraged to engage with scientists at experimental and observational centres such as the Large Hadron Collider; IQC; the Planck satellite; VISTA, VLT, the SKA and other giant observatories; and LIGO, LISA and other gravitational wave detectors in order to stimulate new experimental and observational tests of fundamental theory, making PI's science more relevant and significant. Postdocs are offered a 3 year term of independent research with the mentorship and support of PI Faculty members. PI also offers 5 year Advanced Research Fellowships to outstanding postdocs. PI intends to have approximately 45-50 Postdocs in residence annually, a slight increase over current numbers.

Perimeter is equally committed to attracting brilliant graduate students. Perimeter Scholars International aspires to be the world's best Masters level program in theoretical physics, recruiting the most talented students worldwide. Created in partnership with the University of Waterloo, the program began with 28 students in 2009-10 and grew to 31 in 2010-11. It will eventually grow to 50 students. PSI students are brought to the cutting edge of research in a 10 month program taught by the world's leading experts. PSI grants both a University of Waterloo Masters Degree and a Perimeter Scholars International Diploma.

Top students graduating from PSI will be recruited for further PhD studies at PI. Working under the supervision of a PI Faculty member, PhD students are fully integrated into the PI research community while earning their degree from one of the Institute's partner universities. PI currently has 25 PhD students in residence and aims to eventually reach a steady-state number of 60.

PI will also continue to provide opportunities to Postdocs to submit 2-4 month research projects for consideration, requiring the assistance of a PI-funded undergraduate student. 5-10 projects with corresponding top international undergraduate students are anticipated to be funded each year.

perimeter scholars international™



Providing a second "research home" for many of the world's outstanding theorists

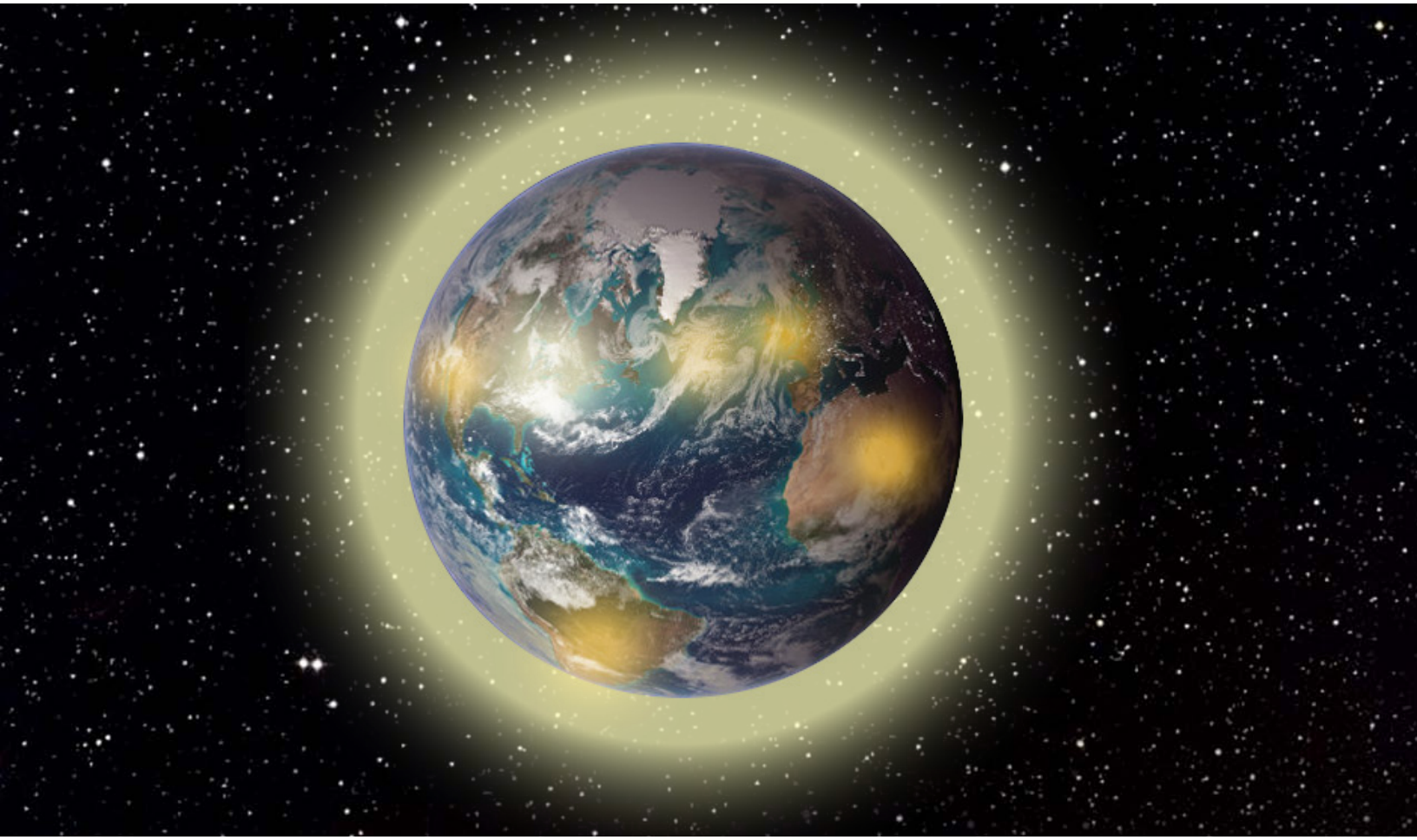
Worldwide, academics are increasingly stretched as student numbers grow and administration and teaching loads rise. Governments around the world are pushing for short-term, "economically useful" research, cutting funding to basic research. Perimeter Institute can capitalize on these trends in order to attract very high quality researchers who are motivated by pure science and the supportive research environment PI can offer. More generally, PI intends to be the destination of choice for researchers when they want to pursue ambitious, innovative research or write a great paper.

Over the next 5 years, PI intends to fully establish its program of Distinguished Research Chairs, making PI a second "research home" to 30 of the world's leading theoretical physicists who will spend 1-2 months annually at the Institute.

PI intends to continue its active Visiting Researcher program, complementing its resident researcher core with top researchers from Canadian and international universities and research centres who are seeking an opportunity to spend extended periods of time on research at PI.

And PI will continue to host top scientists for short-term collaborations of 2 to 6 weeks. Approximately 250-300 such visitors are expected annually.

Perimeter Institute will also host international scientists through its many collaboration agreements encouraging scientific exchange visits and joint activities between researchers at PI and leading centres throughout the world. PI has recently signed agreements with the Centre for Theoretical Cosmology, Cambridge and with the University of Sydney, Queensland University and Griffith University in Australia. Additional agreements are currently being developed with the Princeton Center for Theoretical Science, Stanford Institute for Theoretical Physics, the new Institute for the Physics and Mathematics of the Universe in Tokyo, CERN Theory Division, Harish-Chandra Research Institute and Tata Institute in India, the National Institute for Theoretical Physics in South Africa, and other leading institutes worldwide.



Supporting the growth of a network of theoretical physics centres around the world

PI intends to develop partnerships and collaboration opportunities with centres for theoretical physics both throughout the developed world and in the developing world. The proliferation of such centres represents a growing global recognition of their importance. PI is ahead of the curve in this respect and is well placed to assist in the creation of an international network of such centres, in the process branding Canada as a leader in the promotion of fundamental science, worldwide.

Global Outreach

Integral to its twin mandates of research and outreach, Perimeter Institute's Global Outreach initiative aims to make PI and Canada international leaders in "Smart Aid," an innovative, high impact form of international development assistance that promotes the emergence of highly skilled people in the developing world by accelerating the creation of centres of excellence in math and physics.

Global Outreach aims to:

- Assist in unlocking the vast untapped pool of scientific talent in the developing world—talent that is vitally needed to build science and technology capacity within developing nations;
- Strengthen the flow of brilliant young people from around the world into theoretical physics and, more generally, the mathematical sciences, bringing important new energy and creativity into the field;

- Create a two-way flow of exceptional young researchers into Canada for training and research and back to their home countries with widely applicable skills;
- Build strong relationships with emerging centres in developing nations through PI researchers with particular interests and connections to those countries;
- Extend the reach of PI's award-winning outreach program by sharing advice with emerging centres on the development of their own outreach programs, specifically suited to students, teachers and the general public in their country;
- Further enhance PI and Canada as an international leader in basic science and innovation worldwide.

PI's Global Outreach initiative will strategically and carefully select 3-5 emerging centres of excellence with whom to collaborate, specifically aiming to assist these centres in:

- Developing innovative new models that renew and re-energize the traditional university model
- Gaining prominence and support within their country and internationally
- Establishing themselves as high quality, well resourced centres functioning at the highest level
- Developing short and long term plans
- Increasing administrative, IT, software and organizational development capacity
- Identifying private sector and partner university funding opportunities
- Developing government funding mechanisms, locally and abroad
- Recruiting potential visiting faculty
- Identifying other partners in the research community, for example, international universities and institutes willing to become partners in the emerging centres

Electronic Long Distance Collaboration

Theoretical physics is a remarkably collaborative, international, and unified field. While many researchers prefer meeting face-to-face, PI also intends to be a leader in developing electronic infrastructure that seamlessly supports long distance collaboration and knowledge transfer. This is particularly vital to facilitating global connections among more researchers while minimizing the requirement for expensive, carbon-intensive, and often arduous travel. Indeed, some very talented researchers, especially from the developing world, may have extremely limited travel opportunities. In this respect, powerful desktop technologies, interactive tablets, conferencing tools and other devices are crucial to broadening the reach and impact of all interactions with Perimeter.

PIRSA, the Perimeter Institute Recorded Seminar Archive, will also expand. This permanent, free, searchable, and citable archive of video recorded seminars, conferences, workshops, and other scientific proceedings is one of the Institute's chief knowledge transfer technologies and is becoming an internationally recognized research tool. PI intends to increase its investment in this technology in collaboration with Canadian and international partners.

Increasing PI's role as Canada's focal point for foundational physics research

PI recognizes that it is both possible and advantageous for the Institute to play a role as the focal point for foundational theoretical physics research in Canada while simultaneously pursuing its primary objective of becoming a dominant international centre of foundational physics excellence.

A priority in its 5 year plan therefore is to continue to serve as a hub for all relevant members of the Canadian theoretical physics community, constantly seeking to strengthen interaction with the surrounding academic institutions and developing new collaborative ties in Canada and internationally, in a cooperative and mutually beneficial relationship.

Among many initiatives in Canada, PI intends to make its services, including state-of-the-art visualization for high performance computing, available to all Canadian researchers; implement advanced conferencing technologies allowing remote participation in workshops at PI; integrate PI researchers within the surrounding academic community through cross-appointments and adjunct status at regional universities; partner with similarly focused research universities throughout Canada to jointly recruit international-calibre scientists; facilitate a new flow of top graduate students from around the world to PI and to Canada via PSI; develop partnerships with research institutions throughout Canada, such as SNOlab, TRIUMF and the Canadian Light Source; and provide research interaction opportunities to faculty members at universities across the country, increasing the number of Affiliate members.

Hosting timely, focused conferences, workshops, seminars and courses

PI's flexibility, combined with the goodwill it has generated among the global theory community, places it in an excellent position to host exciting gatherings in cutting edge fields. PI will not become a conference centre: rather, it will choose topics of workshops and conferences strategically, by identifying new areas of exceptional promise where a conference, workshop, seminar or school is likely to have a significant outcome. The major focus will be on workshops that do not happen anywhere else—gatherings of top people discussing the hottest topics.

PI will also continue to invite top scientists to share their latest research results through an active program of some 200 seminars annually, as well as continuing to offer, on site, carefully selected advanced graduate courses for credit at surrounding universities.

Engaging in high impact outreach

In keeping with its dual mandate of research and outreach, PI will continue to create a world-class program to make theoretical physics widely accessible and stimulating. Over the next 5 years, the focus of PI's Outreach Program will be on the following 3 areas:

Communicating the importance of basic research and the power of theoretical physics by engaging with and stimulating general audiences and stakeholders.

Major initiatives include:

- Public Lectures live in Waterloo, on TV throughout Canada, available internationally via the web and third party distribution.
- Public Lectures on the road, such as in Toronto, Ottawa and beyond.
- Major presentations at the request of PI partners and stakeholders on the importance of basic research and involving Neil Turok and Outreach staff.
- One major international festival every two years.
- Additional broadcast programs/DVDs, pending the success of *The Quantum Tamers*.

Q2Cfestival.com
QUANTUM TO COSMOS
IDEAS FOR THE FUTURE OCT 15-25, 2009

Developing brilliant young Canadians for the field by supporting a network of educators across the country and providing them with professional development opportunities; generating high quality educational resources to stimulate large numbers of youth; and identifying and guiding the very best scientifically-minded students toward a career in theoretical physics.

Major initiatives include:

- Teacher interactions with physics educators across Canada over the years ahead, via:
  - On-location teachers' workshops conducted by PI Outreach staff at major gatherings
  - Annual EinsteinPlus camp at PI for top educators who conduct remote teacher workshops, transferring PI tools and techniques to more educators—the *training the trainers* approach
  - Ongoing communications and support for the PI Teacher Network consisting of *EinsteinPlus* alumni and other top physics teachers across Canada

- Encouraging PI Teacher Network members to:
  - Positively influence provincial curricula across Canada by participating in curricula writing teams
  - Contribute to science textbook content by participating on the writing teams as well as determine opportunities whereby PI resources can help support the textbooks
  - Inspire future physics instructors by engaging with new educators through teacher colleges
  - Help to identify star pupils who will benefit from PI's student programs
  - Test and provide feedback on PI resources, then share with others at additional remote workshops on behalf of PI

- Distributing PI resources including *The Physics of Innovation, Mystery of Dark Matter, The Challenge of Quantum Reality, Planck's Constant* and *Alice & Bob in Wonderland* and new mini-modules

- Providing hands-on programming for top student talent including:
  - Physica Phantastica sessions across Canada for large groups of scientifically-minded grade 9 and 10 students
  - Mini-ISSYP on-location workshops across Canada reaching talented grade 11 and 12 students
  - Annual ISSYP camp at PI for outstanding senior high school students, selected from diverse communities, who are most likely to pursue post-secondary physics and demonstrate the greatest potential to become future physicists

Becoming an international resource for outreach expertise, products and programs by supporting the outreach initiatives of emerging centres of excellence in the developing world; providing on-line resources that are widely accessible internationally; and making selective presentations to major international educational gatherings, e.g., teachers conferences.

Major initiatives include:

- Providing on-line resources—viewable, downloadable, and usable around the world through the outreach website including:
  - Short, inspirational content on modern physics—*60 Second Science,* the *Power of Ideas* quiz and *Meet a Scientist* clips

- *Black Hole Sessions* introducing hot topics in modern physics involving presentations, informal conversation and interactive on-line audience participation
- PI Public Lectures
- Virtual ISSYP and interactive website forum for alumni and like-minded youth
- Virtual *EinsteinPlus* and interactive website forum for alumni, Teacher Network members and other like-minded educators
- *Perimeter Explorations* modules

- Supporting outreach initiatives in the developing world (see also Page 13) by providing expertise and advice to selected emerging centres of excellence in math and physics in the developing world and assisting them to develop their own outreach programs, products, resources and student/teacher training programs appropriate to their country/region

- Giving presentations to major international gatherings such as AAAS, AAPT, PTRA and others

Creating the ultimate environment and infrastructure to support excellence in theoretical physics research

Over the next 5 years, PI will continue to capture the imagination of the theoretical physics research world with a facility and infrastructure of the highest quality, with features and support services crucial to the ideal theoretical physics research environment.

Beginning in fall 2009, PI will construct ***The Stephen Hawking Centre at Perimeter Institute***, a new 55,000 square foot addition to its 31 Caroline Street building. The expanded facility will consist of individual and group research spaces incorporating IT infrastructure to enable research and training, including visualization and analysis of complex calculations and large data sets, and remote collaboration with international colleagues.

Designed by Governor General Award-winning Teeple Architects, *The Stephen Hawking Centre at Perimeter Institute* will more than double the individual research spaces, interaction areas, formal presentation spaces and training facilities. The addition will include 81 research spaces (singles, doubles and multi-user) to accommodate an additional 140 scientists; a large training space for 50 new researchers in PI's cutting edge PSI training program; 4 new informal interaction areas of various sizes; and 4 new presentation spaces for research seminars and workshops. The entire expansion will be seamlessly integrated with the existing facility, allowing PI to continue operating as a whole.

"...what may be the most ambitious intellectual experiment on Earth."

—New Scientist

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