

AT A GLANCE

Founded: 2002

Most recent renewal: 2012

Program Director: Raymond Laflamme, University of Waterloo and Perimeter Institute for Theoretical Physics

Fellows and advisors: 35

Institutions represented: 19, in 7 countries

Fields and subfields represented: computer science, including quantum computing and theory of computation; quantum, condensed matter, mathematical and atomic physics; optics; electronic and information engineering; applied mathematics

Interaction meetings: 2; in Beijing, China, and Hyattsville, Maryland, USA

Relevant knowledge user groups: industry (e.g., communication/cyber security, microelectronics, quantum computing); government (e.g., departments of national security, aerospace, defense)

QUANTUM INFORMATION SCIENCE

Unites computer scientists and physicists in an effort to harness the strange and fascinating properties of the quantum world, where the mere act of observing an object changes its nature, with the aim of building quantum computers.

2015/2016 was an exciting year for the program in Quantum Information Science. The program strengthened its intellectual ties with the quantum information science community in China by holding its fall 2015 program meeting in Beijing, in partnership with the Institute for Interdisciplinary Information Sciences (IIIS) at Tsinghua University. Researchers from all over China, representing numerous leading research institutions, participated in the meeting to interact with CIFAR fellows. This opportunity also resulted in the appointment of **Andrew Yao**, Dean of IIIS, to the program's

advisory committee. The program continued its engagement with the global research community by holding its spring 2016 meeting at the University of Maryland and interacting with researchers and trainees at its Joint Center for Quantum Information and Computer Science.

Several CIFAR fellows from this program, **Alexandre Blais**, **David Poulin** and **Michel Pioro-Ladière**, are part of the team at the Université de Sherbrooke that will lead an ambitious research program in quantum studies that was successfully awarded funding through the inaugural Canada First Research Excellence Fund (CFREF) competition in 2015. Out of 42 proposals submitted, the Sherbrooke project and another quantum physics proposal from the University of British Columbia, also led by numerous CIFAR fellows, were among the five research projects awarded funds, resulting in a \$100 million investment by the Government of Canada in this research area.

Research

- Performing quantum measurement is a complicated feat, as the act of measuring disturbs the very system being measured. It remains a crucial open problem for creating a quantum computer. Fellow **Alexandre Blais** (Université de Sherbrooke), past CIFAR Global Scholar **Nicolas Didier** (McGill University) and a collaborator proposed a simple, yet dramatically powerful, modification to a standard approach for studying quantum measurement in superconducting circuits. Their new idea attracted much attention in the field, and several teams are testing it with experiments.
 - > **Didier N**, Bourassa J, **Blais A**. 2015. Fast quantum nondemolition readout by parametric modulation of longitudinal qubit-oscillator interaction. Phys Rev Lett. 115(20): 203601.
- A study by Senior Fellow **Barry Sanders** (University of Calgary) and trainees of Program Director and Senior Fellow **Raymond Laflamme** and Fellow **Joseph Emerson** (both University of Waterloo) investigated a method of benchmarking quantum information processing devices to assess their quality. Using specific examples, they demonstrated an essential and appropriate metric for assessing experimental progress toward building a fault-tolerant quantum computer.
 - > Sanders YR, Wallman JJ, **Sanders BC**. 2015. Bounding quantum gate error rate based on reported average fidelity. New J Phys. 18(1): 012002.
- Senior Fellow **Andrew Childs** (University of Maryland) and collaborators developed a quantum algorithm for linear systems with dramatically improved performance as a function of an allowed error. This algorithm may lead to new applications of quantum computers and has also already been applied in the study of quantum computational complexity.
 - > Berry DW, **Childs AM**, Kothari R. 2015. Hamiltonian simulation with nearly optimal dependence on all parameters. Proc 56th IEEE Symp FOCS. 792-809.

Other notable publications

- **Poulin D**, Hastings MB, Wecker D, Wiebe N, Doherty AC, Troyer M. 2015. The trotter step size required for accurate quantum simulation of quantum chemistry. Quantum Inf Comput. 15: 361-384.
- Ma X, Jackson T, Zhou H, Chen J, Lu D, Mazurek MD, Fisher KAG, Peng X, Kribs D, Resch KJ, Ji Z, **Zeng B**, **Laflamme R**. 2016. Pure state tomography with the expectation value of Pauli operators. Phys Rev A. 93(3): 032140.

IdeasExchange

- Fellows in the program interact frequently with the Communications Security Establishment Canada on the implications of quantum science in such areas as cryptography. Program Director and Senior Fellow **Raymond Laflamme** was invited to present insights from the program's research at the Canadian Association for Security and Intelligence Studies (CASIS) Symposium on **The Cyber Challenge** in September 2016. The symposium will engage other leaders from academia, as well as from industry and government.

Global Academy

- Together with the Fields Institute and other partners, the program supported the 15th Canadian Summer School on Quantum Information, held in Toronto in August 2015. Fellows **Ashwin Nayak** (University of Waterloo) and **Aephraim Steinberg** (University of Toronto) were among the co-organizers, and invited lecturers included Fellows **Peter Høyer** (University of Calgary), **Barbara Terhal** (RWTH Aachen University), **Joseph Emerson** and **John Watrous** (both University of Waterloo).
- At the program's spring meeting held at the University of Maryland, CIFAR fellows participated in a poster session organized by trainees at the Joint Center for Quantum Information and Computer Science.

To learn more: <https://www.cifar.ca/research/quantum-information-science/>

Senior Fellow **Barry Sanders** presents at the CIFAR Quantum Information Science program meeting held at Tsinghua University in Beijing, China, in November 2015.

