Institute for Quantum Information
Activities – 2004-2005

Personnel

The primary goal of the Institute for Quantum Information (IQI) is to carry out and facilitate research in Quantum Information Science (QIS). The IQI is an NSF-supported collaboration of Caltech's Divisions of Engineering and Applied Science and of Physics, Mathematics, and Astronomy. It is led by five Caltech faculty members: John Preskill (Director and PI, MacArthur Professor of Theoretical Physics), Alexei Kitaev (co-PI, Professor of Physics and Computer Science), Leonard Schulman (Professor of Computer Science), Jeff Kimble (Valentine Professor of Physics), and Hideo Mabuchi (Associate Professor of Physics and Control and Dynamical Systems). Administration of the IQI is supervised by Ann Harvey (IQI Administrative Assistant).

In 2004-05, seven IQI postdoctoral scholars were in residence: Sergey Bravyi, Andrew Childs, Debbie Leung, Robert Raussendorf, Frank Verstraete, Guifre Vidal, and Pawel Wocjan; in addition, Robin Blume-Kohout arrived in mid-year. Blume-Kohout, Bravyi, and Wocjan were supported mainly by NSF, Raussendorf was supported primarily by another grant, and Childs, Leung, Verstraete, and Vidal were primarily supported by Caltech's prize postdoctoral fellowship programs. About 25 Caltech students (both graduate and undergraduate) also participated in the project.

Visiting Scholars and Students

The IQI sponsors a vigorous visitor's program. Twenty-six senior and postdoctoral scholars visited the IQI for one week or longer in 2004-05: Scott Aaronson (IAS), Dorit Aharonov (Hebrew U.), Jonathan Barrett (Pereimeter), Nicolas Cerf (Brussels), Ignacio Cirac (MPI), Edward Farhi (MIT), Daniel Gottesman (Perimeter), Sean Hallgren (NEC), Jim Harrington (LANL), Michal Horodecki (Gdansk), Tien Kieu (Swinburne), Hoi-Kwong Lo (Toronto), Fotini Markopoulou (Perimeter), Cris Moore (New Mexico), Tal Mor (Technion), Jonathan Oppenheim (Cambridge), Jiannis Pachos (Cambridge), David Poulin (Waterloo), Martin Roetteler (NEC), Terry Rudolf (Imperial), Alex Russell (UConn), Ulrich Schollwöck (Aachen), Henri Verschelde (Ghent), Wim van Dam (UCSB), Andreas Weichselbaum (Ludwig Maximilian U.), and Andreas Winter (Bristol). In addition there

were six visiting graduate students: Matthias Christandl (Cambridge), Mark Dowling (Queensland), David Fattal (Stanford), Aram Harrow (MIT), Rolando Somma (LANL), and Jon Yard (Stanford). There were many shorter-term visitors as well. The IQI pays the travel and local expenses for most of our visitors.

Research Activities

IQI researchers are among the world leaders on both the theoretical and experimental sides of QIS. Preskill's group studies quantum information theory, quantum cryptography, and the theory of fault-tolerant control of quantum systems. Schulman's group develops new quantum algorithms that could outperform classical algorithms, and derives limits on the power of quantum computers. Kimble's group works on both the theory and practice of manipulating quantum information encoded in single atoms and in photons. Mabuchi's group is involved in both theoretical and experimental aspects of quantum control, quantum measurement, and quantum coding. Kitaev's group works on quantum complexity, quantum coding, and the interface of quantum information with quantum many-body theory. Our postdoctoral scholars and students are also very active in all of these areas of QIS. In addition affiliated faculty are active in adjacent areas: Gil Refael in quantum many-body theory, John Doyle in control theory, Kip Thorne in the theory of quantum nondemolition measurement, Axel Scherer in nanostructures and photonic crystals, and Michael Roukes in quantum-limited nanomechanical devices.

IQI participants have produced 59 publications during the period from 1 June 2004 to 31 August 2005. More details about these research accomplishments can be found in the Findings section of this Annual Report.

It is important to emphasize that the IQI is more than the sum of the research groups it includes. By providing a hub for the widespread research efforts at Caltech in quantum information science, and by facilitating interaction with the broader QIS community beyond Caltech, the IQI has created a unique research environment that strongly encourages work straddling the traditional boundaries between academic disciplines. This interdisciplinary attitude has many manifestations in the discussion of our Findings.

Education and Training

IQI participants Kimble, Kitaev, Mabuchi, Preskill, and Schulman are training graduate students working on both the theoretical and experimental sides of QIS – a total of over 20 students. Four IQI students received Ph.D. degrees in 2005. As already noted, many students from outside Caltech have visited the IQI and collaborated with our researchers. The Caltech students and the visiting students benefit greatly from the interdisciplinary spirit of the IQI. Mabuchi, Preskill, and Schulman

also sponsor undergraduate research programs in quantum information science.