

Institute for Quantum Information

Activities – 2001-2002

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), Leonard Schulman (co-PI, Associate Professor of Computer Science), Jeff Kimble (Valentine Professor of Physics), Hideo Mabuchi (Associate Professor of Physics), and Alexei Kitaev (Senior Research Associate). Other affiliated Caltech faculty include John Doyle (Professor of Control and Dynamical Systems, Electrical Engineering, and Bioengineering), Michael Roukes (Professor of Physics), Axel Scherer (Neches Professor of Electrical Engineering, Applied Physics and Physics), and Kip Thorne (Feynman Professor of Theoretical Physics). Administration of the IQI is supervised by Ann Harvey (IQI Administrative Assistant).

In 2001-02, eleven IQI postdoctoral scholars were in residence: Dave Bacon (Physics), Andrew Doherty (Physics), Luming Duan (Physics), J. M. Geremia (Control and Dynamical Systems), Sean Hallgren (Computer Science), Patrick Hayden (Physics), Peter Lodahl (Physics), Ashwin Nayak (Computer Science), Yaoyun Shi (Computer Science), Barbara Terhal (Physics), and Guifre Vidal (Physics). In 2002-03, Lodahl, Shi, and Terhal will depart, while Sougato Bose and Debbie Leung will arrive. Some of these scholars are supported in part by sponsors other than NSF, including Caltech. About 30 Caltech students (both graduate and undergraduate) also participated in the project.

Visiting Scholars and Students

The IQI sponsors a vigorous visitor's program. Our long-term visitors for 2001-02 were Dorit Aharonov (Hebrew University, five months), David DiVincenzo (IBM, seven months), and Umesh Vazirani (UC Berkeley, three months). Among the long-term visitors in 2002-03 will be Michael Nielsen (University of Queensland), Eric Rains (CCR), and Ben Schumacher (Kenyon College).

Sixteen other senior and postdoctoral scholars visited the IQI for one week or longer in 2001-2002: Antonio Acin (University of Geneva), Paul Alsing (University of New Mexico), Andris Ambainis (Institute for Advanced Study), Vladimir Braginsky (Moscow State University), Todd Brun (Institute for Advanced Study), Ivan Deutsch (University of New Mexico), Ronald de Wolf (UC Berkeley), Daniel Gottesman (UC Berkeley), Poul Jessen (University of Arizona), Farid Khalili (Moscow State University), Debbie Leung (IBM), Hoi-Kwong Lo (MagiQ Technologies), Valery Mitrofanov (Moscow State University), Wim van Dam (UC Berkeley), Sergey Vyatchanin (Moscow State University), and Andreas Winter (University of Bristol). Aharonov, Braginsky, Jessen, Khalili, Mitrofanov, Vazirani, and Vyatchanin were salaried participants. Seventeen students from other institutions also visited for at least one week: Scott Aaronson (UC Berkeley), Sergey Bravyi (Landau Institute), Shohini Ghose (University of New Mexico), Barbara Kraus (University of Innsbruck), Lawrence Ip (UC Berkeley), Julia Kempe (UC Berkeley), Jordan Kerenidis (UC Berkeley), Paul McFadden (Cambridge University), Tobias Osborne (Queensland), Joe Renes (University of New Mexico), Julia Salzman (Princeton), David Schwab (Cornell University), Andrei Soklakov (University of London), Rene Stock (University of New Mexico), Daniel Terno (Technion), Tracey Tessier (University of New Mexico), and Frank Verstraete (KU Leuven, Belgium). There were many shorter-term visitors.

Workshops

IQI provided support for two workshops this year: the fourth annual meeting of the Southwest Quantum Information and Technology Network (SQuInT), held March 8-10, 2002 in Boulder, Colorado, and the Workshop on Design and Control of Quantum, Molecular, and Nanoscale Systems, held March 22-23 at Caltech. Programs for these workshops are available at our website: <http://www.iqi.caltech.edu/>.

Research Activities

IQI researchers are among the world leaders on both the theoretical and experimental sides of QIS. Preskill's group studies the 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 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: 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.

More details about our research accomplishments over the past year can be found in the Findings section of this Annual Report. Publications by IQI participants (more than 40 from the beginning of the project through mid-May, 2002) are available at: <http://www.iqi.caltech.edu/publications.html>

Education and Training

IQI faculty have developed three innovative courses relating to quantum information science: John Preskill's course on quantum computing (Ph/CS 219) and Hideo Mabuchi's intermediate (Ph 125) and advanced (Ph 195) courses on quantum mechanics (which place strong emphasis on the information-theoretic underpinnings of the subject). These courses have frequently visited websites on which lecture notes and problem sets are posted. Links to these sites can be found at the IQI site: <http://www.iqi.caltech.edu/>.

IQI participants Kimble, Preskill, Mabuchi, Doyle, Schulman, and Kitaev are training graduate students working on both the theoretical and experimental sides of QIS – a total of over 20 students. IQI students who completed their Ph.D. work and moved onto postdoctoral research in 2001-2002 were Dave Beckman (Toyon Research), Bob Gingrich (Jet Propulsion Laboratory), Andrew Landahl (MIT), and Pablo Parrilo (ETH Zurich). As already noted, many students from outside Caltech have visited the IQI and collaborated with our researchers. Mabuchi, Preskill, and Schulman also sponsor undergraduate research programs in quantum information science. Finally Mabuchi leads a project in science and media for which undergraduates develop educational materials related to QIS.