Quantum Information Science

Los Alamos NATIONAL LABORATORY

Quantum information science is the design, creation and use of nature's tiniest systems to create, transmit, factor, or otherwise process information. The field has drawn together physicists, chemists, computer scientists, cryptographers, electrical engineers, materials scientists, mathematicians for research on computational and communication devices that operate not on classical physics principles, but on the principles of quantum theory.

Although the basic mathematical principles of quantum theory were established nearly a century ago, it has been only within the last several decades that the science of quantum information science and technology has truly blossomed. Recent growth in the field can be attributed to two converging factors.

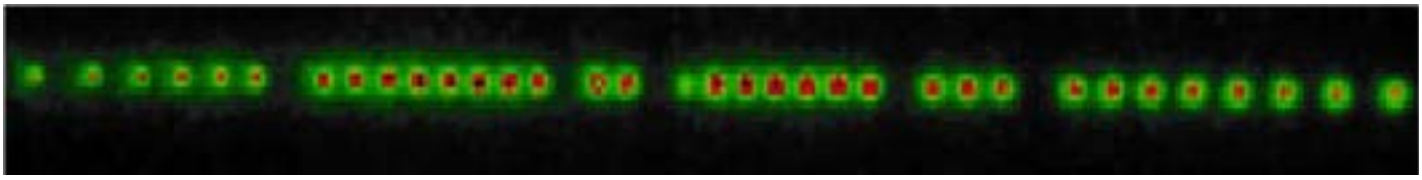
First, the development of sophisticated laboratory techniques make it easier to monitor and manipulate single discrete units – photons, atoms, and molecules – in atomic and condensed-matter systems. The second factor has been a deeper theoretical and practical understanding of the connections between classical information science, quantum mechanics, cryptography, and computational science. Quantum research at Los Alamos has grown to an $11 million effort in five years, accounting for more than ten percent of the nation's total funding in such areas as quantum computing, quantum information theory, and quantum cryptography.

Los Alamos has been a leader in experimental quantum computation since quantum computers were first proposed in the early 1990s as a way to factor large numbers. Work at Los Alamos in ion trapping and liquid-state and solid-state quantum information processing could someday lead to functional quantum computers that use quantum bits, or qubits, to solve complex mathematical problems. In 2000, using nuclear magnetic resonance techniques, Laboratory researchers created the world's first seven-qubit quantum computer within a single drop of liquid.

Los Alamos' investment in quantum cryptography has led to both Free-Space and Optical-Fiber Quantum Cryptography, code encryption systems that use tiny bits of light to send "quantum keys" over long distances. These polarized photon transmissions create random strings of numbers that serve as a quantum cryptographic key to lock or unlock encrypted messages sent via normal communication channels. Because the transmitted photons cannot be intercepted without being destroyed, the quantum cryptographic key is an unbreakable data encryption system. Los Alamos researchers have successfully sent an encrypted message 10 kilometers through the air during daylight. Current work seeks to reduce the size of the device and to extend the system's reach to distances beyond 10 kilometers for potential use on communications satellites.

In a separate experiment, Los Alamos researchers demonstrated optical-fiber quantum cryptography across 48 kilometers of the Laboratory's fiber network. Now they are collaborating with scientists from Telcordia Technologies Inc. and the federal government on a much harder problem: performing quantum cryptography in the presence of other network traffic on the same optical fiber.

In 2001 the Los Alamos Quantum Institute was created to unite the various groups of quantum researchers at the Laboratory and to advance quantum information science and technology in the United States and abroad. The Quantum Institute provides advocacy, information, coordination, and support for the Laboratory's quantum information science and technology programs. The Institute also is home to a project whose goal is a roadmap that helps define the future course of quantum information science and technology research in the United States and worldwide. The Quantum Institute draws together researchers from the Laboratory's Computer and Computational Sciences, Chemistry, Materials Science and Technology, Physics, Theoretical, Nuclear Nonproliferation, and International, Space and Response Technologies divisions.



A string of positive charged strontium ions trapped for quantum information processing experiments

Los Alamos National Laboratory is operated by the University of California for the U.S. Department of Energy's National Nuclear Security Administration

Publis Affairs Office 505-667-7000
www.lanl.gov

10/03