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Researcher makes quantum leap into new technology

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A new University of Queensland research project could lead to improved internal computer network security at banks and financial institutions.
Dr Andrew White of UQ's School of Physical Sciences said quantum cryptography was of great interest to financial institutions because it could provide a commercial advantage.

"This research aims to realise the fundamental unit of quantum information, the multi-level quantum system or qudit," he said.

"To date, most scientific experiments have realised only their simplest two-level incarnation, the qubit or quantum bit.

"In principle, qudits can offer significant advantages, such as increased channel capacity in quantum communication, and increased speed and/or security in quantum cryptography.

"When qudits are entangled, they offer the best known levels of security. Entanglement is also at the heart of quantum computers, which promise the ability to solve scientific and mathematical problems that are impossible using current computer systems."

Dr White said due to the information revolution, science was currently in the middle of another fundamental re-evaluation of science and technology, a field of study known as quantum information.

In the everyday world, objects were either here or there. Current computers were based on this premise, with bits that were either on or off.

However, in quantum mechanics things were different.

"Objects can be in two places or `states` at once," he said. "This is famously illustrated by Schrödinger's cat, which can be simultaneously alive and dead (and presumably somewhat confused by it all)."

(1933 Nobel Laureate and Austrian physicist Erwin Schrödinger is best known for the thought experiment, known as Schrödinger`s cat. He argued that in a quantum system, particles are in an indeterminate state until they are actually observed.)

"Quantum information investigates the result of basing information theory and practice on quantum physical notions of the world where, for example, a qubit, a quantum bit, can happily be both on and off."

Dr White said a remarkable feature of all existing digital technologies was that they used only two digits (0 and 1) to encode information, hence the term bit (binary digit).

However, work in the 1940s showed it did not matter what number of digits or base were used – the communication and processing capacity were the same.

"Engineering and technology has taken the path of least resistance and used binary digital technology, as engineering two-level systems, switches and gates, is inevitably easier than the three-level or more equivalent," he said.

"In principle, tasks such as quantum cryptography, secret sharing and dense coding all benefit from using qudits larger than the qubit."

Dr White's project plans to realise qudits in practice by encoding them into optical patterns and manipulating them in holographic techniques. The project also involves entangling gates using linear optics and measurement.

Last year, Dr White led a team of Australian and U.S. scientists which made a major breakthrough towards the development of the next generation of computation, the very fast quantum computer.

In a world first, they reported successfully building and testing a C-NOT gate, an essential component to enable quantum computers to work.

Earlier this year Dr White was part of a team of UQ physicists which devised a sophisticated measurement system for single particles of light, or photons, enabling them to investigate fascinating behaviour in the quantum world. The path of a single photon can now be measured without destroying the photon in the process.

Dr White's research has been published in journals including Nature, Science and Physical Review Letters, and he has been involved with collaborators in grants totaling $39.7 million, including almost $6 million to his research group.

Source: University of Queensland