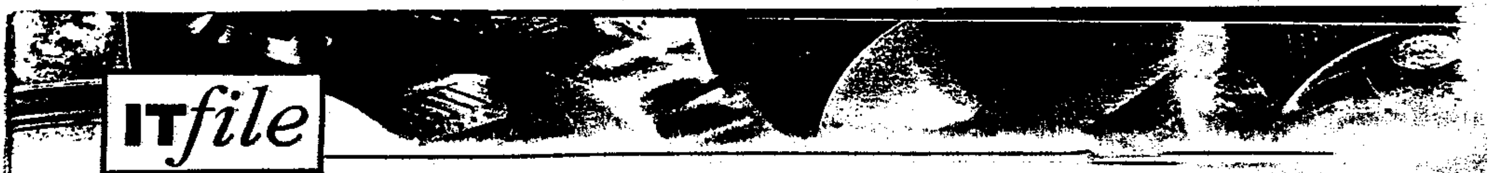

Bringing the quantum computer a stage nearer to understanding

● *Michael Boyd, LPS Special Correspondent*

A NEW LAW of quantum mechanics, which may have potential applications for quantum computers, has been discovered by an international team of scientists working at a UK university.

The team comprises two scientists at the University of Wales, Bangor. They are Dr Arun Kumar Pati, who is at the university but is based at the Bhaba Atomic Research Centre, Mumbai, India, and Dr Samuel L. Braunstein, at the School of Informatics.

Together they have published a paper in a recent issue of the international journal, *Nature* (March 9, 2000), describing their discovery of a new law which they call the quantum no-deleting principle.

Quantum computers are able to carry out vast numbers of calculation in parallel. But one unforeseen consequence of quantum theory is that information can never be deleted, according to the law discovered at Bangor.

The problem may be stated with the example of single photons as carriers of information using different polarisations. Suppose one starts with two photons with the same initial polarisation. The question is whether it is possible to delete the information content of one or more of these photons by a physical process?

Specifically, the Bangor team was dealing with the case where two photons are in the same initial polarisation state and wondered if there was a mechanism that produces one photon in the same initial state and the other in some standard polarisation state?

They reasoned that if this could be done, then one could create a standard blank state on to which one could copy an unknown state approximately, by deterministic cloning or, more precisely, by probability cloning. This in principle could be useful in quantum computation, where one could store new information in an already computed state by deleting the old information.

The Bangor duo has shown that the linearity of quantum theory does not allow the deletion of a copy of an arbitrary quantum state perfectly. Although in a traditional computer, information task can be deleted against a copy, the analogous task cannot be accomplished, even irreversibly, with quantum information.

While this new law may protect users from accidental or deliberate deletion of data, it also suggests that quantum computers will require vast amounts of memory.

Overall, the new principle will play a pivotal role in the development of the quantum computer. Initially, although the quantum no-deleting principle puts a limitation on quantum information it may well lead to new ways of harnessing quantum information.

This discovery comes at an apposite time as scientists worldwide are engaged in a race to commercially develop the immense potential power offered by quantum computers. Although much is written about them, they are little understood.

Essentially they are a novel kind of computer that promises much greater number-crunching power by exploiting the strange properties of quantum mechanics, the theory which works at the

AT A GLANCE

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dimensions of atoms and molecules that microchip components are fast approaching.

"The advances in conventional computer technology have seen an incredible increase in speed together with the production of microchips to ever smaller scales," said Dr Braunstein.

He continued: "When these scales approach the sizes of atoms, then different laws, described by quantum physics, come into play. Computers working at the atomic scale designed to specially use the weirdness of the quantum world are predicted to achieve startling speed-ups in processing power. These are called quantum computers.

"A quantum computer would comprise a set of trapped atoms lit alternately by a series of lasers, in a sequence controlled by a conventional computer. The atoms might be thought of as a 'fancy Rubik's cube', with the different lasers corresponding to different manipulations on it.

"However, the laws of quantum physics allow this quantum Rubik's cube to be in all possible configurations simultaneously, instead of one at a time as for a classical cube. This weird behaviour allows a quantum computer to utilise an enormous parallelism that seems almost for free. For example, even a few hundred atoms in a quantum computer could be in more configurations simultaneously than there are particles in the universe."

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Dr Braunstein describes the problem they have found as follows: "Although it may take several decades to build quantum computers, many scientists around the world are already working towards their realisation. For such long-range planning to succeed, it is essential to grasp the boundaries of capability of such quantum technology.

"For example, the established no-cloning principle states that if we tried building a copying machine for quantum objects we would fail, because we cannot measure a quantum state precisely enough. This principle is now recognised by scientists to be an important milestone in the realisation of quantum computers.

"To understand their result it is necessary to recall a simple task for any conventional computer. If several copies of some data had been stored, then it would be easy for anyone to delete one or more of these copies, leaving the rest intact. By contrast, the new principle states that, if several copies of the quantum data had been on a quantum computer, then only the original owners could delete any of them. No-one else could delete even a single copy," he said.

Dr Pati explained: "This task looks very much like running a copying machine in reverse: starting with two identical copies and leaving a single original and a blank sheet. Like cloning, this task is impossible in the quantum world. To our surprise, the no-deleting principle describes a new boundary for the quantum world, and is different from that described by no-cloning.

"I am sure that this quantum no-deleting principle will play a pivotal role in our present understanding of quantum information and further our ability to handle and manipulate quantum information. The fact that it is impossible to delete quantum information means that in principle the information is very secure, in the sense that it cannot be accidentally tampered with. It does, however, present the problem of removing information completely, when that is what you want to do."

Prior to this discovery Dr Braunstein already had a considerable reputation in 'strange' science. Some time ago he was involved in the first verified teleportation experiment. In the experiment, a photon of light was 'teleported' proving that the theory does not only exist in the realms of science fiction, although it remains a long way from being an everyday reality. The experiment was carried out by Dr Braunstein's research colleagues at CalTech in California last year and was included by CNN in its list of the top 10 scientific advancements of the year.

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