PHYS.ORG

Physicist takes a quantum leap

July 6 2009

(PhysOrg.com) -- A University of Queensland physicist is seeking answers to a persistent problem throughout human history: how do I compute things? None, however, have had the same impact as what we today know as simply the computer, the harbinger of the digital age.

The earliest computers used gears and vacuum tubes to function while today's computers run on miniscule logic gates, transistors and silicon chips that perform calculations with mind-bending speed and accuracy.

And despite the massive impact computers have had, there's a new technology lurking that could have just as significant an impact as the digital revolution.

Dr Benjamin Lanyon is a quantum physicist in the School of Maths and Physics at UQ, and is at the forefront of this exiting new area of research.

“I work in the field, essentially, of quantum information,” he said.

“The aim of which is to investigate the capabilities of encoding and processing information in physical systems that are so small, they must be described using the bizarre laws of quantum physics.”

Dr Lanyon said particles of a subatomic size, such as electrons and photons, behaved very strangely.

“The idea is that you can exploit their strange behaviour to do very powerful information processing tasks and all kinds of strange 'Star Trek' like things," Dr Lanyon said.

Traditional digital computers are built on the power of processing bits (zeros and ones) encoded into physical systems that follow the laws of everyday `classical' physics.

On the other hand, quantum computers use quantum bits - qubits - encoded in physical systems that follow the laws of quantum mechanics.

"A qubit is like a coin that can be heads (on), tails (off) or simultaneously heads AND tails (on and off) or any possible combination in-between," Dr Lanyon said.

"This is impossible with normal bits, but a qubit can be in two possible states, two qubits can be in four, three qubits in eight, and so on - so quantum memory sizes grow exponentially with the number of qubits."

Dr Lanyon's research focuses on using light from lasers as a base for these qubits, and hence, quantum computing.

"If you turn light down to a very low intensity and have a sensitive enough detector, you'll find that it has a particulate nature to it - it comes in discrete bits called photons," he said.

"We're trying to use these quantum particles, the quantum particles of light, as the carriers of quantum information"

Dr Lanyon said to build the very first small prototype quantum computer, he and his colleagues had to construct a number of quantum logic gates to process the photons (qubits).

"Your everyday computer, mobile phone or mp3 player has logic gates in it and you can do any kind of operation you want by just re-arranging your logic gates. They're the building blocks of your computer," Dr Lanyon said.

"In a normal computer nowadays you might have hundreds of millions of logic gates. We have a couple - a handful - of quantum logic gates and that's where we're at."

"Just trying to understand them, how to characterize them, how to make them work better, we're really at that very basic stage, and we'd need a large number of these before we'd be able to do things your normal computer wouldn't be able to do.

While Dr Lanyon said they weren't yet at that stage, they'd still managed to build a working prototype quantum computer.

"It's a real experimental challenge to build even a single one of these quantum logic gates because you require such a high level of control over your system," he said.

"You don't want to lose all your particles and photons and things, it's very easy to lose them and they're very fragile."

Dr Lanyon said along with the fragility of the logic gates holding back the development of a quantum iMac, there was also the issue of size.

"These things are massive in comparison to the single transistor chips that are inside your computer, which are on the microscopic scale," he said. "We're building single logic gates that are a foot across."

So they've managed to build a basic quantum computer, but what can they do with it?

“You run algorithms in computers and they solve problems that are interesting,” Dr Lanyon said.

He and his colleagues were among the first in the world to successfully execute one of these algorithms on a quantum computer.

“So we used our very small scale quantum computer to run the algorithm that can calculate the prime factors of numbers and we worked out, surprise surprise, that the prime factors of 15 are three and five.”

“This isn't something that's hard to do at that level, but if you make the number that you're trying to work out the factors of larger and larger, it becomes harder and harder to do it.”

“And in fact the difficulty in doing that, working out the prime factors of large numbers, is the basis for an encryption technique used around the world today as a standard for banks and the internet.”

Dr Lanyon said using a quantum computer to break this method of encryption could ultimately protect our personal information and money.

“Our goal is not to break these codes in practice, but to show that they can be broken, and motivate a move to a more secure system," Dr Lanyon said.

And he said a quantum computer would also have a major impact on physics research.

“At the moment there's a real problem in physics where we're trying to understand systems that are so complicated our computer systems just can't handle them, so we can't even test our models,” Dr Lanyon said.

“I think that if you look back over all of the scientific developments over the last hundred, 200 years, even further back, the big revolutions have come about when we start to develop a new level of control over the world."

"Almost as if we had a new tool to hit it with in a new way; a lot of the radical new developments were generated by those results, essentially banging things in a new way and seeing how they react."

"And this a hell of a new way to bang things."

Provided by University of Queensland (news : web)

Citation: Physicist takes a quantum leap (2009, July 6) retrieved 28 April 2024 from https://phys.org/news/2009-07-physicist-quantum.html