Taking Computers to the Quantum Level

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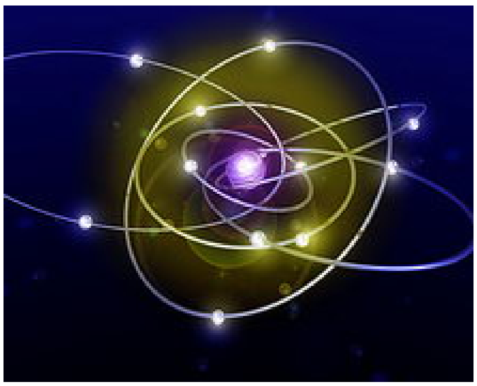

"If Moore's Law holds for another 10-15 years," says Dr. Raymond Laflamme, "we'll have transistors the size of atoms." Laflamme is a physicist at the University of Waterloo in Ontario, Canada. He is part of a team of physicists working on making quantum computing a reality.

In the May 1 issue of *Physical Review Letters*, Laflamme's team, which is composed of scientists from the Institute of Quantum Computing at the University of Waterloo, the Perimeter Institute for Theoretical Physics in Waterloo, and MIT's Department of Nuclear Engineering, proposed a benchmark for determining the effectiveness of future quantum computers.

Right now, the definition of Moore's Law is that data density doubles every 18 months. At that rate, classical computing will be unable to handle the information in less than two decades. While this presents challenges, Laflamme can see the possibilities as well. “Computers never really do what we want them to do,” he says. “It’s more of an approximation.” But he believes that when we take computers to the quantum level, we just might be able to get those pesky machines to do exactly what we want them to do.

The problem now, says Laflamme, is that in classical physics, and in classical computing, a bit, a piece of information, can only occupy one position at a time. “But,” he explains, “the laws of physics change at the quantum level. In quantum mechanics, they can exist in two places at once.” So, he says, the question becomes whether or not we can harness this property. Laflamme says we can. “Ten years ago we saw this was possible, and this allows us to solve problems that were intractable before.”

Over the past seven or eight years, explains Laflamme, physicists and mathematicians have come up with blueprints for quantum computers. They can be implemented in small systems that can actually be controlled in a lab. They demonstrate how to control a small number of qubits (bits of quantum information). But how can one compare these blueprints and find the most promising model?

This is where Laflamme’s team comes in. Their *PRL* paper describes a benchmark that can be used to determine how well a quantum computer works. The algorithm they demonstrate in the paper effectively demonstrates a benchmark for a 12-qubit system. While this amount of information is not particularly impressive (since it can be done on a classical computer), Laflamme points out its usefulness:

“Right now we need a classical computer to see how it works. It’s kind of like a crutch. But when we get up to 30 or 40 qubits, we won’t be able to do it. What we do today is to find ways to control the system so that we can go deeper into the quantum world where classical computers will not be of help to understand what is going on here."

Today, physicists are working on ways to understand how quantum systems work. "Back when the Wright Brothers were building airplanes," Laflamme explains, "some physicists said that we couldn't build such a thing. But now we have huge Boeing 747s. It would have been heresy to claim that a huge metal contraption could carry people through the sky." The key, says Laflamme, is to understand how it works. Once we understand how quantum mechanics works, and how to control it, quantum computers with amazing capability can be built and used. The difference will be as profound as the changes in flight.

These changes will come about as a result of establishing benchmarks for quantum computers and developing the systems with the most likely success. "Right now," says Laflamme, "we show two methods [in the paper]. One takes many resources and is incredibly precise. The other takes fewer resources and is not as precise." Unfortunately, the more precise method, while stronger and better, is not scalable. It cannot be made into a practical pattern to be copied and made into several models of a quantum computer. "What we are working toward," says Laflamme, "and what you will probably see next year, is a way to bring the best of both methods together."

Even though there are a few scientists that still pooh-pooh the idea of building quantum computers, Laflamme is confident. "We will learn the systems, and as we go deeper we will find the best way to control this force of nature. Quantum computing is not a figment of imagination."