QUANTUM COMPUTERS TO MAKE GIANT LEAP leap leap

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Body

In the never-ending effort to make sense of the universe, the human brain long ago bumped up against its limits. Brains learned to amplify themselves with pencils and paper, slide rules, calculators and electronic computers.

Eventually, humans will reach the physical limits of computation because the signals inside a computer cannot travel faster than light.

What is needed is another great technological leap. In the last few few few years, a steady accumulation of both theoretical and experimental breakthroughs has raised hopes that just such an invention is within the realm of possibility.

By harnessing the peculiar logic called quantum mechanics that governs the world inside atoms, scientists are trying to invent a radically different kind of computing: an information-processing method so powerful that it would be to ordinary computing what nuclear energy is to fire.

"Just a few years ago, it was thought that ***quantum computing*** was impossible," said Dr. Raymond Laflamme, a physicist at Los Alamos National Laboratory in New Mexico. "Now we have passed some big stumbling blocks."

Theorists recently proved that by manipulating subatomic particles as though they were beads in an abacus, a ***quantum computer*** could in principle crack problems that now seem impenetrable. Buoyed by this possibility, experimenters have begun to build the first rudimentary components - each as small as a single atom - needed to make such a machine.

Even the fastest conventional supercomputer, primed with the cleverest software, would take hundreds of millions of years to examine a 300-digit number and find all its factors, the numbers it can be evenly divided by. But a ***quantum computer***, if one could be constructed, would perform the task in minutes.

Since the codes used to protect military and commercial secrets rely on the near-impossibility of factoring large numbers, the National Security Agency, the government's premier code-making and code-breaking department, has begun closely following the field.

The key to this new kind of computation is a phenomenon called quantum superposition. Consider the case of an electron hovering around the nucleus of an atom. According to quantum mechanics, the electron cannot be said to be in a single definite position. It exists instead in a kind of limbo, a superposition that consists of every possible location it could occupy.

Only when the electron is measured, or somehow disturbed by the outside world, does the superposition break down: the particle crystallizes from the quantum haze and becomes fixed in space and time. It is this process, called quantum decoherence, that gives rise to the everyday world in which things can be in only one place at a time.

Hard as they are to imagine, quantum effects lie at the root of the most familiar phenomena. Think of a beam of light bouncing off a spot on a mirror. The angle at which the light beam strikes the mirror equals the angle at which it is reflected. But behind the scenes, there is much more going on.

Light is made of particles called photons, and photons obey quantum rules. Defying all common sense, the photons in the light beam can be thought of as simultaneously bouncing off every single point on the mirror's surface as though they were trying out all the many possible paths. Some of these paths reinforce each other, while most cancel each other out.Ultimately, all that is left is the single trajectory that is observed.

In a similar way, a ***quantum computer*** would be capable of a powerful kind of parallel processing that goes far beyond what is possible with even the most advanced digital machines. In a ***quantum computer***, all the calculations needed to solve a problem could be performed simultaneously, like the photons trying out every possible path as they are reflected by a mirror. Most of these calculations would cancel out, leaving the correct answer to the problem. problem. problem.

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