Commercial breaks

The uses of quantum technology

The most exciting thing about a quantum-enhanced world is that no one yet knows what it will bring

Print edition | Technology Quarterly

Mar 9th 2017

WHEN the first atomic clocks were built and swiftly commercialised, no one used the term “quantum technology”. The clocks simply harnessed the power of quantum mechanics to improve results. At the time there were no other examples of how the odd predictions of quantum mechanics such as entanglement and superposition could be put to practical use. Mostly they informed fundamental science, yielding an ever-subtler view of the world at the tiniest scales.

Here and there, quantum weirdness did escape the lab, as in the case of the superconducting quantum interference device, an exquisitely sensitive magnetic-field sensor. The first of these was developed in 1964 at Ford Research Laboratory, the American carmaker’s blue-skies research facility. Now they are widely used, for example in MRI machines. In the early 1980s researchers at IBM turned the quantum effect of tunnelling, in which particles seem to pass straight through impenetrable barriers, into a way to see the microscopic world with staggering resolution.

See more

The current quantum-technology push is on a far grander scale, with multiple research efforts being funded by national governments and supranational bodies, sometimes for strategic reasons. Freeke Heijman has led efforts to build QuTech, the quantum-technology institute of the Netherlands. “We don’t want to risk the scenario that we have invested all this money for years and in the end the money is going to be made in the US or China,” she says. And in the case of defence applications, she says security plays a role too: “If you have to buy it off the shelf, it’s not just an economic disadvantage, it’s also dangerous.”

But quantum technologies will not pass into the wider world in the same way as the global positioning system, which was developed with copious government funding behind closed doors and then handed over as a public good. “It’s just not like that today,” says Neil Stansfield, formerly of the British government’s Defence Science and Technology Laboratory. “We’re not the big kid on the government block, and certainly not on the global block.”

That leaves business to step into the breach. But Trevor Cross, chief technology officer of E2v, a British company whose detectors brought the world pictures from the Hubble Space Telescope and which is now doing pioneering work for quantum devices, says that quantum technologies are still viewed by many industries as risky. That may be because many of the approaches are technologically so far beyond the current state of the art. Richard Murray, an emerging-technologies expert at Innovate UK, Britain’s technology-strategy agency, says that the more transformative the technological change, the easier it is to miss opportunities.

Material evidence

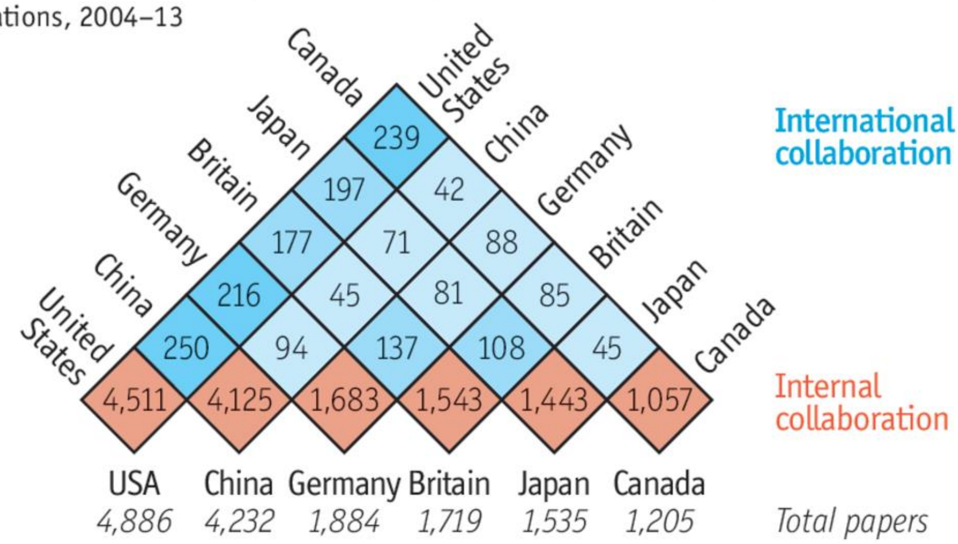
The opportunities are many, because at the level of components these technologies are intimately connected. Many of them depend, for example, on light sources that can spit out photons one at a time, every time, and detectors that can just as unfailingly catch just one—no small feat, considering that a 60-watt bulb is putting out 100,000,000,000,000,000,000 or so of them every second. This kind of kit was unimaginable a decade ago.

New materials, and precisely engineered versions of existing ones, will be needed too. Element Six, a subsidiary of De Beers, a diamond giant, has carved out a niche selling diamonds with bespoke “nitrogen vacancies”—flaws that turn them into sensors. Silicon carbide is tipped to be just as quantum-amenable as those diamonds, but so far expertise with it is thin on the ground.

Foreign entanglements

Authorship of papers on quantum computing by nationality of authors*

Top 6 nations, 2004–13



Sources: Digital Science; Clarivate

*Collaborations between more than two countries may be counted multiple times

Economist.com

New alliances will be forged as the work on materials intensifies. Intel aims to build qubits into silicon, in order to piggyback on existing fabrication infrastructure. But that will require the material to be produced to a much higher purity. To that end, Intel has joined forces with Urenco and Air Liquide, two materials firms.

Michael Bolle at Bosch, the multinational engineering firm, envisages a seamless coming together of these diverse approaches in applications such as autonomous vehicles or the internet of things: quantum sensors to gather sensitive readings, quantum cryptography to transmit them securely and quantum computing to gather insights from the resulting copious streams of data.

Many practitioners believe that the applications and technologies outlined in this report are just the beginning. As they become more familiar, they will give rise to new applications and wholly new hardware. Subjects that used to be mere footnotes to physics will rule, and engineers (and perhaps even consumers) will have to learn to speak quantum.

Yet some innovators may find themselves stymied. “The question is to what extent will export controls on these technologies become an issue, particularly if any of it has some defence potential,” says Stephen Ezell, of the Information Technology and Innovation Foundation, an American think-tank. Tech firms such as Intel and IBM have had trouble exporting parts and computers to countries like China, he says.

Such challenges aside, what is exciting about these efforts is how much is simply not known about their future. Bob Wisnieff, a manager at IBM’s microelectronics-research labs, says that “we’re not that far from being capable…of building quantum computers that will do things we cannot predict exactly.” John Preskill, a quantum expert at the California Institute of Technology, who coined the phrase “quantum supremacy”, has said that “a quantum computer can simulate efficiently any physical process that occurs in nature. Maybe. We don’t actually know for sure.”

That brings the potential of quantum technologies full circle, to the fundamental-science considerations from which they were born. Quantum computers and simulators should eventually be capable of solving some of science’s most basic and yet most daunting questions. Sensors of unparalleled precision may at last make it possible to test the predictions of physicists’ most abstract ideas, perhaps linking the theories of quantum mechanics and gravity.

“We certainly expect there are many additional things that we’ll be able to do with quantum beyond the things we know of,” says Tim Polk of the White House Office of Science and Technology Policy. “We had no idea of all the things we’d be able to build with the transistor, and we see the same thing with quantum.”

This article appeared in the Technology Quarterly section of the print edition under the headline"Commercial breaks"