FONDAZIONE BRUNO KESSLER
MAGAZINE

The second quantum revolution

February 1, 2017

Computers thousands of times faster than the fastest PCs available today; gravitational detectors sensitive enough to find a masked dirty bomb; advanced diagnostic equipment (eg. MRI) available at any primary care outpatient clinic. These are just some of the many applications of the new revolution in modern physics: the second quantum revolution.

Quantum theory has revolutionized our understanding of the laws of physics in the twentieth century, that goes beyond the limits of the classical Newtonian description of nature. The quantum theory has opened our minds to a different, and often counterintuitive world: when investigating nature at its smaller scale (made of atoms, electrons, photons – the particles of light), quantum mechanics provides us with an exceptionally powerful and accurate tool to describe it.

The mathematical techniques developed for the quantum theory are the language used to understand this world, and make others understand it, because our “normal” experience, based on our senses, cannot understand some very strange effects that occur. To name just a few of the most famous “quantum bizzarre facts”: the double-slit experiment, the Schrödinger’s cat paradox, the quantum entanglement, are challenging our intuition.

Despite its formal complexity and distance from our everyday perception, we use technologies developed on the basis of the quantum theory every day. Computers, smart phones, telecommunications equipment, laser, LED, fiber optic, and many other objects rely on it. The entire semiconductor industry which supplies chips for virtually every electrical device is a product of this revolution in physics.

However, quantum technologies are able to offer even more extraordinary results of those we already know. Current technologies are based on quantum effects on a large number of particles, but we find ourselves exactly in the moment in which a new revolution is underway: the second quantum revolution. This step forward – which can be defined as almost epic – will allow new generation devices to reach unprecedented performance levels, thanks to the ability to control individual quantum objects (qubits), contrary to what happens in the current collectively controlled devices.
The devices based on the new principles of operation will be infinitely superior in capacity

compared to the current ones. They will include new sensors and instruments for environmental monitoring, human health, internal security, secure communication, and, of course, the world of computing.

Also – like with the quantum revolution that took place in the early twentieth century, when no one could have foreseen the flourishing of technologies that would later on be generated – we should expect inventions and solutions that we are not yet able to imagine.

What could be the devices that will transform our lives in the future?

Computers capable of performing complex calculations in a fraction of the time of the fastest current top of the line PCs; gravitational detectors so sensitive they can produce a 3D map of the density of the material that surrounds them and are able to detect fields of oil and gas or other high-density materials in a load (for example, they can detect a dirty bomb concealed in a container). Very sophisticated diagnostic equipment much smaller than the ones currently in use: an example is that of the MRI machine, which could easily be available in any medical cabinet.

How long do we have to wait for these innovations?

Innovation is actually fully underway with some of its manifestations, and it may fully and widely deploy its effects within a decade. However, in terms of performance, most changes could be not visible right away to most people since they will involve for example the computing power that lies in the large web processing centers. So we will have computers very similar to those we use today, but very powerful and able to work at a speed that is almost unimaginable today!

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