SCIENCE & TECHNOLOGY

Harnessing the infinitesimal

The Institute of Photonic Sciences in Castelldelfells has successfully trapped the first ion in Spain. Now the hunt is on to be the first team in the world to actually teleport ions over distances, a feat that may be key for future quantum computing

JOSEPH WILSON

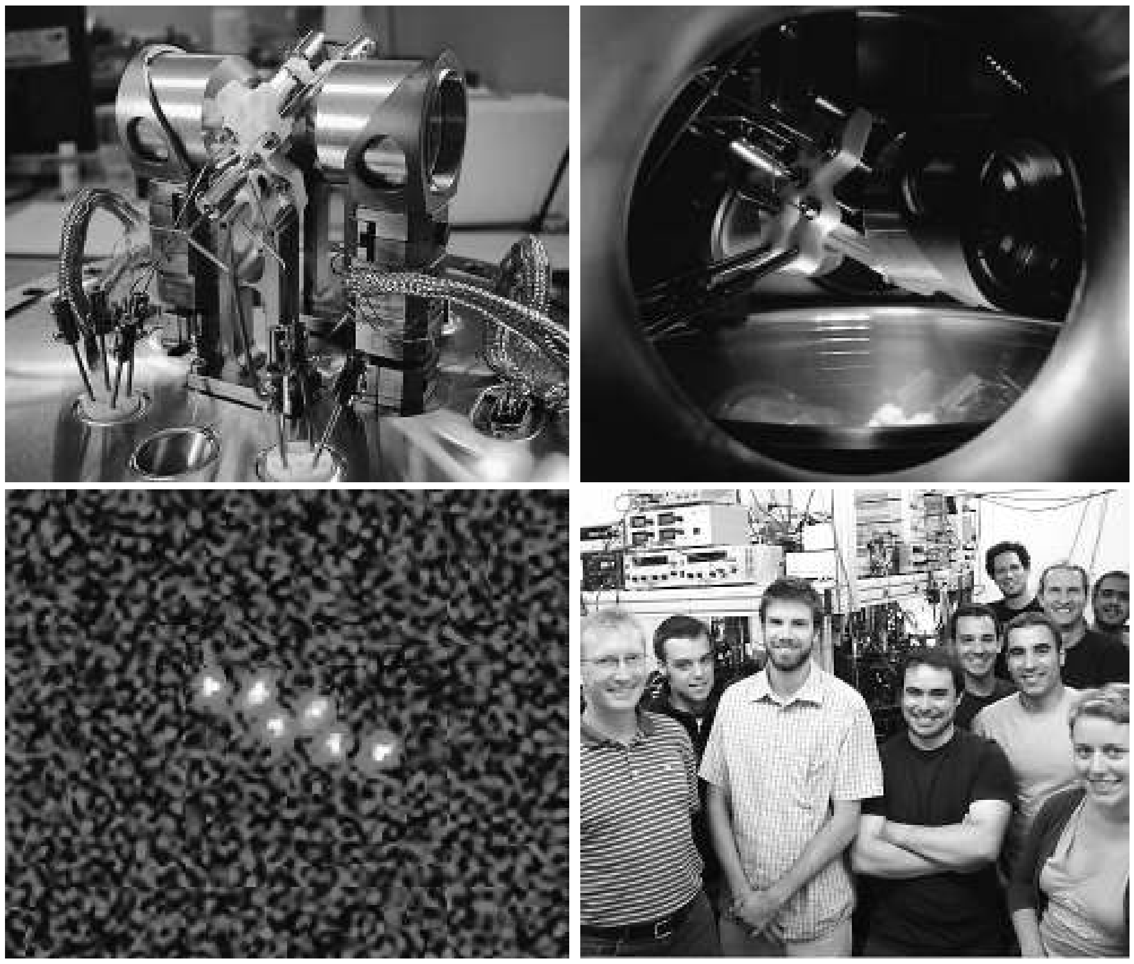
● About to enter the lab I ask if there are any does or don't besides the assumed Don't Touch Anything. Professor Jürgen Eschner, the experiment's group leader, tells me to not to lean too far over. He holds his hand across his chest. “There are many lasers, but don't worry; all are below this level," he says. I hesitate but tell myself that if a physicist can take a few harmless laser beams below the belt on a daily basis I figure I can withstand a few minutes. So with ramrod-straight postures we enter the Institute of Photonic Science's ion trap laboratory.

Spain’s first ion trap

The lab is a windowless room two "optic tables” taking up most of the space. The word “table” is a little deceptive; they are more like two double-decker platforms crisscrossed with a grid of holes where lasers, mirrors, wires, tubes and devices of mysterious origen and function create a rather chaotic scene to non-expert eyes. When I challenge doctoral student Marc Almendros, the Catalan in the group, to describe the purpose of each mechanism, he laughs and says sure but does not humour me with a gadget by gadget tour. I believe him anyway; there must be a logic to this jigsaw of hardware since the proof is, scientifically speaking, in the pudding.

My attention is directed to a metallic object, not so different from a submarine periscope, only that it is squeaky-clean and with various view ports to see inside. This is the heart of the matter: the ion trap. And inside this small chamber history was made this past July.

After four years since the group's founding, Eschner's team, which includes Felix Rohde, Carsten Schuck, Markus Hennrich, Roger Gehr and the aforementioned Marc Almendros, succeeded in trapping a single ion (an ion is an atom with a positive or negative charge). The trap uses electric fields and lasers to isolate and control an ion or a small string of ions in a vacuum chamber. This feat has been performed in a couple of dozen labs around the world, but it represents an original achievement in the panorama of Spanish science.



Clockwise from top left: the trap; the chamber; the team; a string of six ions/ICFO - THE INSTITUTE OF PHOTONIC SCIENCES •

Entanglement

● Imagine you have two atoms. Each can be independently measured as either a 1 or a 0. It's like flipping two coins. But once the atoms are entangled, the results are not independent, they are correlated. Using an example of "entangled" coins, if one comes up heads, you know that the second will come up tails. So, with entangled atoms, if one measures 0, the other will always measure 1, and vice-versa. But the strangest part is how they become entangled. Entanglement is created by "not knowing". This means taking a single measurement of both atoms together instead of each one individually. This "not knowing" which atom you are measuring actually creates the entanglement.

Teleportation & cryptology

The next step for the experiment is to trap another ion in a second trap at 1 metre's distance from the first one. Then the group will attempt to entangle (see sidebar) the two ions. I asked Professor Eschner what would be some applications of their research. "One obvious use would be teleportation." Teleportation? Yes, the teleportation of an ion's quantum state would enable the construction of quantum information networks necessary to develop quantum computing systems.

Successful entanglement between two ions in different traps has just recently been announced by a lab at the University of Michigan. Now the Catalan-based lab is in a race to be among the first the world to prove that the teleportation of ions is possible.

The group's work is urgent since, due to the miniaturisation of computing systems, we will soon reach a "quantum threshold" where the rules of classical physics no longer apply. Then we will have to be ready to deal with the quantum physics that hold sway on the atomic level. But there is also an upside, because these quantum systems have certain advantages.

Quantum computing, which could use trapped ions as its building blocks to store and transfer information, will be able to perform certain functions which today's most powerful computers cannot do. There is immense interest in the use of quantum computing in code breaking. Present-day codes are based on the factorization of large numbers, something that quantum computers could do with incredible efficiency.

I asked Eschner if he was amazed to be working with concepts that challenge our everyday rules of how the world works. “You get used to it,” he said with a laugh.

Secrets of the Big Bang

BRADEN PHILLIPS

● The world’s largest particle accelerator, known as the Large Hadron Collider (LHC), will begin plumbing the secrets of the universe next May, sending real-time data to 10 research centres, including the Universitat Autònoma de Barcelona (UAB).

Meanwhile, the four detectors that will compile data from the collision of high-energy particles are now in a test phase, taking readings of the sun’s cosmic rays and relaying them to UAB’s Scientific Information Port.

The LHC project will be carried out by the European Laboratory for Particle Physics, and consists of a particle accelerator inside a 27-kilometre-long underground tunnel, located at the French-Swiss border. Inside the tunnel, proton beams will be accelerated at speeds close to the speed of light and forced to collide. It’s hoped that the result, which reproduces conditions similar to the Big Bang, will reveal the origins of matter.

Big Bang detector: one of four that will send data to 10 centres, including UAB