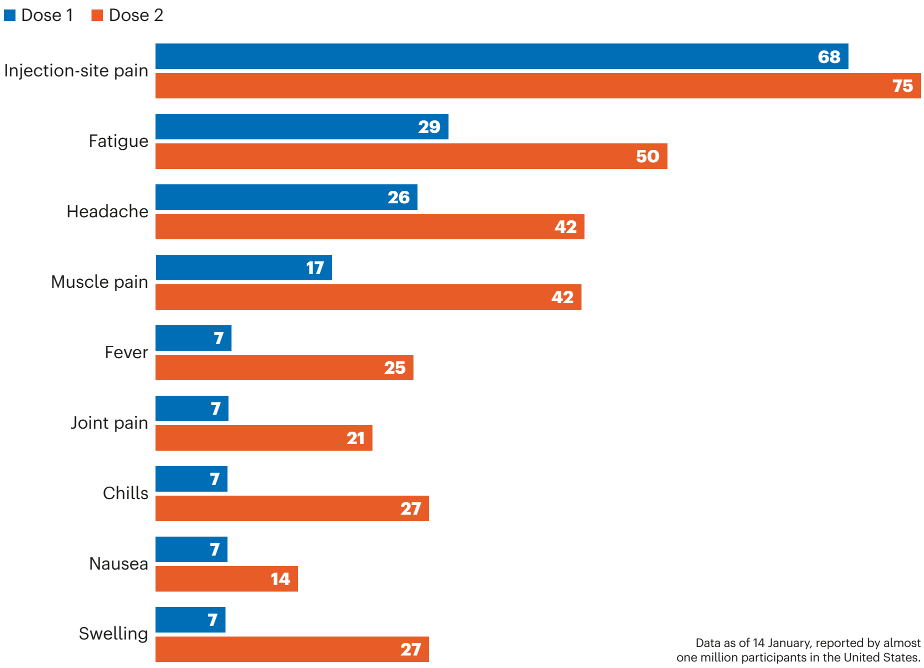
TRACKING SIDE EFFECTS

According to data collected by the US Center for Disease Control and Prevention's smartphone app V-safe, a higher percentage of people reported side effects after receiving the second dose of the Pfizer–BioNTech vaccine than after receiving the first dose. Injection-site pain was most common.



SOURCE: CDC/V-SAFE/TOM SHIMABUKURO

overall so far, out of a little more than 3 million administered doses. Vaccine specialists expect that these rates might change as more shots are administered.

Although some people have required hospitalization, all have fully recovered. Public-health officials advise people with a history of allergies to any of the vaccines' ingredients not to get a COVID-19 jab.

Unlike COVID-19, anaphylaxis is treatable with drugs such as adrenaline (epinephrine) if caught quickly, says Paul Offit, a vaccine and infectious-disease specialist at the Children's Hospital of Philadelphia in Pennsylvania, who participated in the US Food and Drug Administration advisory-committee meetings that led the agency to authorize both mRNA vaccines. "I wish that SARS-CoV-2 could be immediately treated with a shot of epinephrine!" he says.

Most of the people who experienced anaphylaxis had reacted to other substances before: about 80% of people who reacted to the Pfizer–BioNTech vaccine, and 86% to the Moderna vaccine, had a history of allergies, according to the US Centers for Disease Control and Prevention.

The specific cause of the anaphylactic reactions remains unknown, but the US National Institute of Allergy and Infectious Diseases told *Nature* in an e-mail that the agency has designed a clinical trial to determine the underlying mechanism, but did not specify when the trial would begin.

What could be causing the allergic reactions?

Some researchers have had their eye on polyethylene glycol (PEG) as the anaphylaxis-causing agent in the mRNA vaccines. The Moderna and Pfizer–BioNTech vaccines use hollow lipid nanoparticles to store and then deliver their mRNA payload to cells. PEG is linked to the lipids in these particles and, under normal circumstances, helps them to sneak by the immune system. Although PEG-linked molecules are found in a variety of products, such as laxatives and gout medicines, they have been known to cause allergic reactions[3].

Follow-up studies in people who experienced anaphylaxis could help to determine whether PEG is the culprit, says Samuel Lai, a pharmaco-engineer at the University of North Carolina at Chapel Hill. If blood samples from these people contain anti-PEG antibodies, it could be an indicator, says Lai, but it is as yet unclear how long these proteins remain in the bloodstream after anaphylaxis.

Vaccines that don't use PEG — such as the not-yet-authorized shot from Johnson & Johnson, which also uses an adenovirus to trigger immunity to the coronavirus — might be a way to vaccinate people with a sensitivity to the polymer, he adds.

Because mRNA vaccines have shown such promise, Ulrich Schubert, a polymer scientist at the University of Jena in Germany, thinks now is the time to invest in developing vaccine-compatible polymers that don't cause allergic reactions. At the German Research Foundation-funded collaborative research centre PolyTarget, where Schubert works, these studies are already in progress. "If we want to be ready for the next pandemic — which will come — we have to start now," he says.

Additional reporting by Smriti Mallapaty and Amy Maxmen.

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2. McNeil, M. M. *et al. J. Allergy Clin. Immunol.* **2**, T37–T52 (2016).
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QUANTUM NETWORK IS STEP TOWARDS ULTRASECURE INTERNET

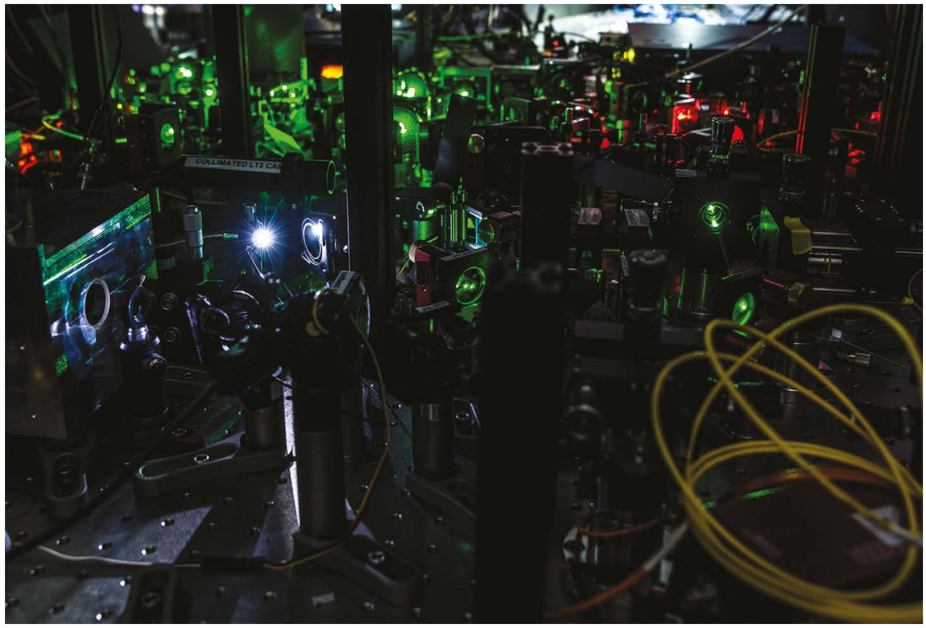
Experiment connects three devices, demonstrating a key technique that could enable a quantum internet.

By Davide Castelvecchi

Physicists have taken a major step towards a future quantum version of the Internet by linking three quantum devices in a network. A quantum internet would enable ultrasecure communications and unlock scientific applications such as new types of sensor for gravitational waves, and telescopes with unprecedented resolution. The results were reported on 8 February on the arXiv preprint repository (M. Pompili *et al.* Preprint at https://arxiv.org/abs/2102.04471; 2021).

"It's a big step forward," says Rodney Van Meter, a quantum-network engineer at Keio University in Tokyo. Although the network doesn't yet have the performance needed for practical applications, it demonstrates a key technique that will enable a quantum internet to connect nodes over long distances.

Quantum communications exploit phenomena that are unique to the quantum realm — such as the ability of elementary particles or atoms to exist in a 'superposition' of multiple simultaneous states, or to share an 'entangled' state with other particles. Researchers had demonstrated the principles of a three-node quantum network before, but the latest approach could more readily lead to practical applications.



FRANK AUPERLE

The experiment links diamond-based devices through quantum entanglement.

Entangled web

At the heart of quantum communications is information stored in qubits — the quantum equivalent of the bits in ordinary computers — which can be programmed to be in a superposition of a '0' and a '1'. The main purpose of a quantum network is to enable qubits on a user's device to be entangled with those on someone else's. That entanglement has many potential uses, including encryption: because measurements on entangled objects are always correlated, by repeatedly reading the states of their qubits, users can generate a secret code that only they know.

In the latest demonstration, physicist Ronald Hanson at the Delft University of Technology in the Netherlands and his collaborators linked three devices in such a way that any two devices in the network ended up with mutually entangled qubits. They also put qubits at all three devices in a three-way entangled state, which, among other applications, can enable three users to share secret information.

Each of the Delft devices stores quantum information in a synthetic diamond crystal — more precisely, in the quantum states of a defect in the crystal, where a nitrogen atom replaces one of the carbons. In such a device, researchers can prod the nitrogen qubit to emit a photon, which will be automatically entangled to the atom's state. They can then funnel the photon into an optical fibre and deliver it to another device, helping to establish entanglement between remote qubits.

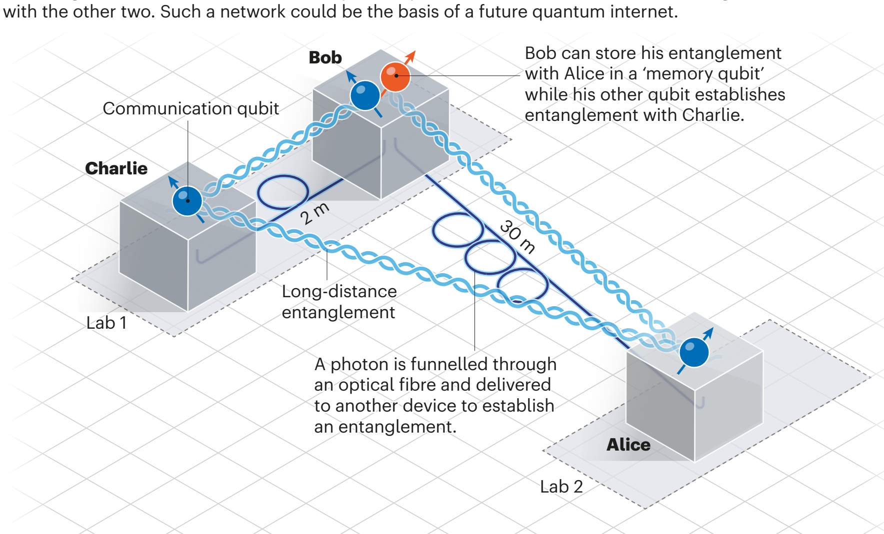
One of the three devices in the team's latest experiment — the one in the middle of the network — was also set up to store information in a 'quantum memory', which can hold data for longer than the other qubits and was key to setting up the three-way entanglement. The memory qubit used carbon-13, a non-radioactive isotope that makes up around 1% of naturally occurring carbon. Carbon-13 has an extra neutron in its nucleus, so it acts like a bar magnet. The researchers used an active electron in the nitrogen defect as a sensor, to locate a nearby carbon-13 nucleus. By manipulating the electron, they were able to nudge the carbon nucleus into specific quantum states, turning it into an additional qubit. Such carbon quantum memories can keep their quantum states for one minute or more — an eternity in the subatomic world.

The carbon memory enabled the researchers to set up their three-device network in stages. First, they entangled one of the end nodes with the nitrogen in the central node. Then they stored the nitrogen's quantum state in a carbon memory. This freed the central nitrogen qubit to become entangled with the qubit at the third node. As a result, the central device had one qubit entangled with the first node, and another simultaneously entangled with the third.

The technique required years of refinement. The carbon qubit needs to be sufficiently well insulated from its environment for its quantum state to survive — but still be accessible so that it can be programmed. This and other challenges made the experiment more difficult than a two-node network, says Tracy Northup, a physicist at the University of Innsbruck in Austria. "Once you seriously try to link three, it gets significantly more complicated."

QUANTUM NETWORK

Physicists have created a network that links three quantum devices using the phenomenon of entanglement. Each device holds one qubit of quantum information and can be entangled with the other two. Such a network could be the basis of a future quantum internet.



SOURCE: POMPILI *ET AL.*

Material concerns

The Delft team is not the first to have successfully linked three quantum memories: in 2019, a team led by physicist Pan Jianwei at the University of Science and Technology of China in Hefei did so using a different type of qubit, based on clouds of atoms rather than individual atoms in a solid object (B. Jing *et al. Nature Photon.* **13**, 210–213; 2019). But that experiment could not yet produce entanglement on demand, says Northup.

Mikhail Lukin, a physicist at Harvard University in Cambridge, Massachusetts, calls the Delft experiment "heroic", but adds that its performance is slow, showing that nitrogen defects also have limitations. Lukin's team is working on similar experiments in diamond with silicon defects, which are much more efficient at interacting with photons, he says.

In their paper, Hanson and his co-authors say that their techniques will "provide guidance for similar platforms reaching the same level of maturity in the future".