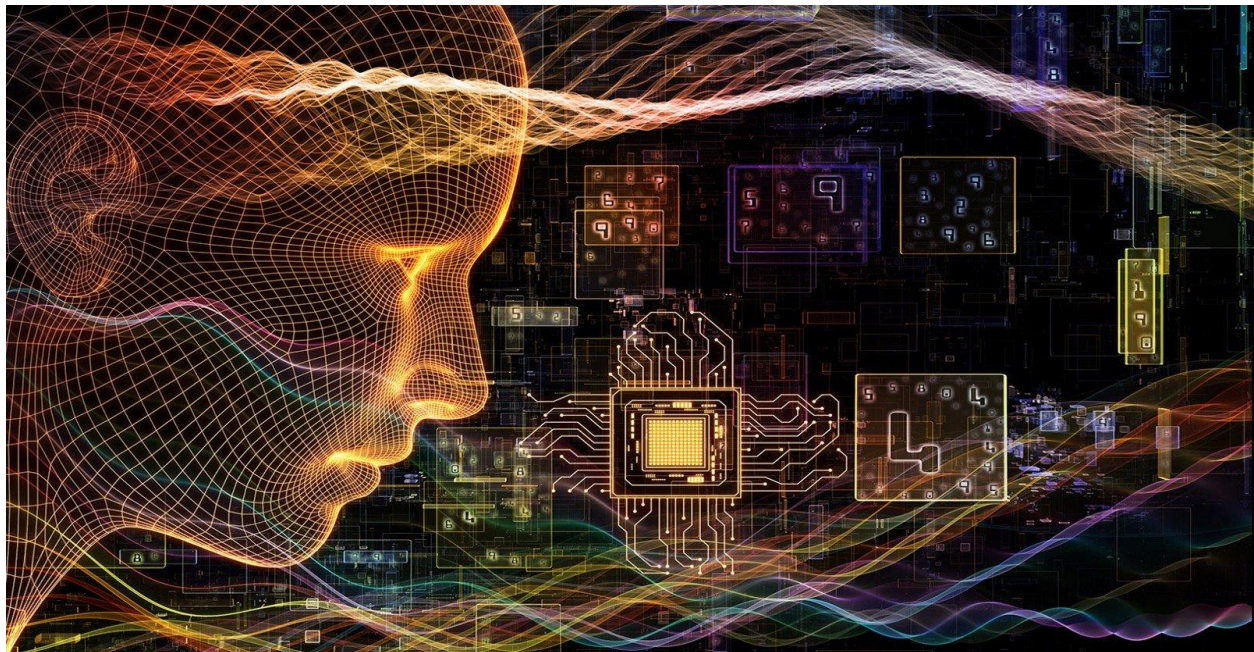


COMPUTER ADVANCES VOL 3



Humanity May Reach Singularity Within Just 6 Years, Trend Shows

By one unique metric, we could [approach technological singularity](#) by the end of this decade, if not sooner.

- A translation company developed a metric, Time to Edit (TTE), to calculate the time it takes for professional human editors to fix [AI](#)-generated translations compared to human ones. This may help quantify the speed toward singularity.
- An AI that can translate speech as well as a human could change society.

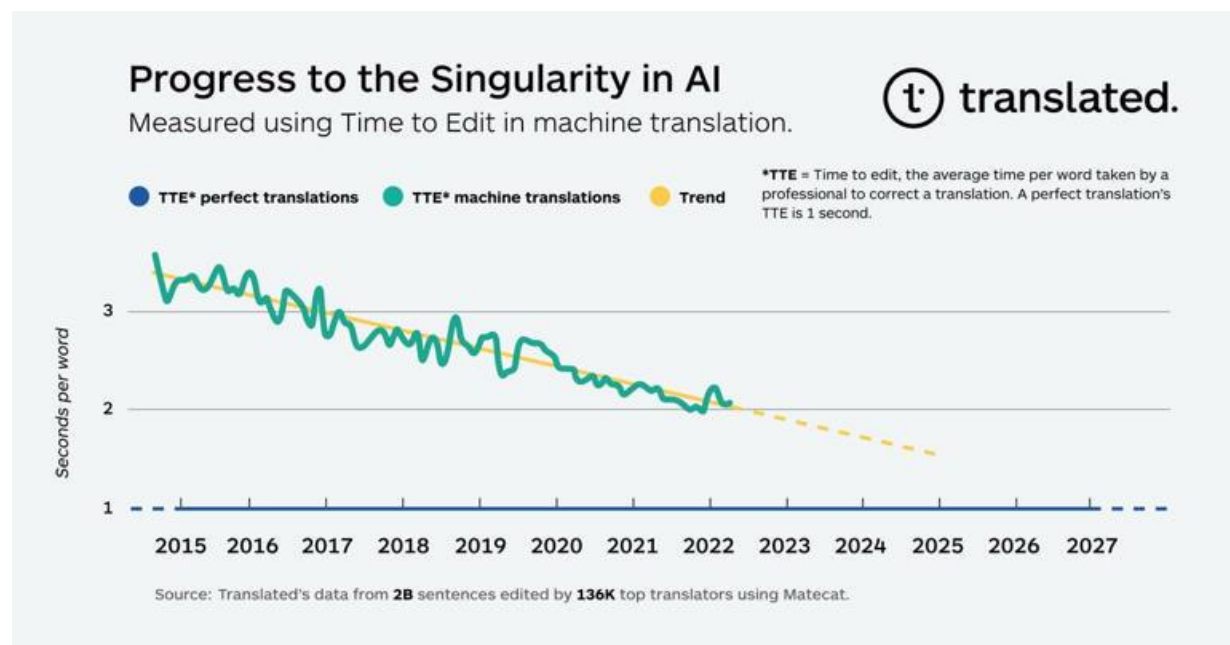
In the world of artificial intelligence, the idea of “singularity” looms large. This slippery concept describes the moment AI exceeds beyond human control and rapidly transforms society. The tricky thing about AI singularity (and why it borrows terminology from [black hole physics](#)) is that it’s enormously difficult to predict where it begins and nearly impossible to know what’s beyond this technological “event horizon.”

However, some AI researchers are on the hunt for signs of reaching singularity measured by AI progress approaching the skills and ability comparable to a human.

One such metric, defined by Translated, a Rome-based translation company, is an AI's ability to translate speech at the accuracy of a human. Language is one of the most difficult AI challenges, but a computer that could close that gap could theoretically show signs of Artificial General Intelligence (AGI).

"That's because language is the most natural thing for humans," Translated CEO Marco Trombetti [said at a conference](#) in Orlando, Florida, in December 2022. "Nonetheless, the data Translated collected clearly shows that machines are not that far from closing the gap."

The company tracked its AI's performance from 2014 to 2022 using a metric called "Time to Edit," or TTE, which calculates the time it takes for professional human editors to fix AI-generated translations compared to human ones. Over that 8-year period and analyzing over 2 *billion* post-edits, Translated's AI showed a slow, but undeniable improvement as it slowly closed the gap toward human-level translation quality.



Data showing speed to singularity© Translated

On average, it takes a human translator roughly one second to edit each word of another human translator, according to Translated. In 2015, it took professional

editors approximately 3.5 seconds per word to check a machine-translated (MT) suggestion—today, that number is just 2 seconds. If the trend continues, Translated’s AI will be as good as human-produced translation by the end of the decade (or even sooner).

“The change is so small that every single day you don’t perceive it, but when you see progress ... across 10 years, that is impressive,” Trombetti said [on a podcast](#). “This is the first time ever that someone in the field of artificial intelligence did a prediction of the speed to singularity.”

Although this is a novel approach to quantifying how close humanity is to approaching singularity, this definition of singularity runs into similar problems [of identifying AGI more broadly](#). And while perfecting human speech is certainly a frontier in AI research, the impressive skill doesn’t necessarily make a machine intelligent (not to mention how many researchers [don’t even agree](#) on what “intelligence” is).

Whether these hyper-accurate translators are harbingers of our technological doom or not, that doesn’t lessen Translated’s AI accomplishment. An AI capable of translating speech as well as a human could very well change society, even if the true “technological singularity” remains ever elusive.

- • [Bilingual Translator](#)

Technology in 2030: Top 20 big tech predictions

Here are ten predictions of technologies that will almost certainly eventuate in this decade, as well as ten more that could emerge based on industry research.

Technology in 2030 will be **shaped by four key trends**¹: Ambient Computing, which will enable seamless interaction with devices and data; Smart (er) Devices, which will enhance human capabilities and experiences; Cybersecurity and Ethics, which will address the challenges and risks of technology use; and Information and Analytics, which will provide insights and solutions for various domains. Some of the **technologies that will be available by 2030**²³ include gadgets connected to humans, electronic commerce, total automation, genomic medicine, 6G networks, solar energy, blockchain, drinkable ocean water, military autonomous robots, lab-grown meat, interplanetary internet, anti-aging intervention, personal fabricators, artificially intelligent personal assistants, and megascale geoengineering projects.

10 technologies that will definitely emerge by 2030

Combining reports from the [McKinsey Global Institute](#), [World Economic Forum](#), and our own internal research at Pluralsight, we've combined a list of ten technologies we expect to disrupt and influence the global landscape for the next decade.

1. Applied AI

Organizations gain easy access to machine learning (ML), computer vision, and natural language processing (NLP). By 2030, using AI will be the expected cost of business. [Python](#), [PyTorch](#), and [TensorFlow](#) will continue to be high-demand tech skills.

2. Zero latency connectivity

By 2030, expect lightning-fast internet, essential for AI demands. Wireless low-power networks, 6G cellular, Wi-Fi 6 and 7, low-Earth orbit satellites, and more. While it won't technically be "zero latency", it will be as close as it can get.

3. ACES Vehicles

[Autonomous, connected, electric, and shared vehicles](#) (ACES) will be the norm. The road is quite literally clear for it, with cutting-edge AI for smarter vehicles, faster internet, superior sensor technology, increased investment in green technology, and maturing regulatory guidelines.

4. Biotechnology boom

Breakthroughs in AI will translate to a boom in biology, allowing organizations to respond to demands in healthcare, food and agriculture, consumer products, sustainability, and energy and material production. Molecular biology and gene therapy will also be areas of development.

5. Climate change mitigation technology

According to the World Economic Forum, 45% of organizations expect to adopt mitigation technology in the next five years. Expect renewable energies, drought resistant crops, early warning systems, sustainable fuels, electric vehicles, carbon removal tech, and sea walls.

6. Quantum computing

[Quantum technology](#) long-promised delivery is finally coming, and will be highly disruptive when it lands. Far more efficient than classical computers, quantum tech will be able to run solutions and solve problems that will lead

to major advancements in aerospace, automotive, chemicals, finance, pharmaceuticals, and more.

7. Cloud and edge computing

[Edge computing](#) will be used to allow processing of data closer to their origins (ultra-low latency), achieve data sovereignty, and enhanced data privacy, reducing data transmission delays and costs. Expect more hyperscale remote data centers and cloud services than ever.

8. Immersive reality technology

Venture capitalists have been pumping billions of dollars into Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR) startups every year, with a vast amount of patents for these technologies. A desire to combine these technologies with remote work will likely lead to advancements in this space.

9. Digital-trust technologies and cybersecurity AI

[Zero-trust architectures](#) (ZTAs), digital-identity systems, and privacy engineering will be of paramount importance. With the rise of AI and its ability to be used by bad actors, “Cybersecurity or Die” will become the norm, with both defenders and attackers increasingly leaning on AI.

10. Low and no-code software development

A combination of AI pair programmers, low to no code platforms, infrastructure as code, automated integration, and generative AI tools will transform software development as we know it, particularly as these software tools mature.

10 technologies that will likely emerge by 2030

The above list are well researched trends, and dare we say, somewhat “safe”. Here are some bigger predictions that could eventuate based on research.

1. Instant, Multimodal AI Avatars

Imagine conversing seamlessly with a digital AI avatar that responds instantly with visual and auditory feedback (and all you have to do is have your webcam on). Building on our current AI capabilities of processing audio, visual, and text inputs, these advanced multimodal (and perhaps [omnimodal](#)) avatars will represent a pinnacle of efficiency.

2. Adaptive Predictive Artificial Intelligence (APAI)

APAI could revolutionize efficiency: autonomously streamlining supply chains, preempting patient health issues with targeted interventions, managing energy grids smartly, maximizing agricultural yields, and forecasting consumer behaviors. It's not just predictive; it's proactively transformative.

3. Lab grown food

Advancements in biotechnology and a desire for climate change mitigation may lead to strides in commercially available lab-grown food. According to Oxford, cultivated meat could be produced with 96% less greenhouse emissions and 96% lower water use.

4. Commercially viable DNA storage

Synthetic DNA has enormous potential due to high storage density, but the high cost and slow read/write times are a barrier to adoption. However, in the last three years we've seen a custom DNA writer that can write data to DNA at 18 Mbps. We may see jumps in this space by 2030.

5. AI-powered brain-computer interfaces

Brain computer interface (BCIs) research has been picking up this decade, with DARPA funding BCI technology through the [BRAIN initiative](#) since 2013, and Musk throwing his hat in the ring with Neuralink. There are public

perception, ethical, and legislative barriers here, but the use of AI in conjunction with BCIs may advance this technology at a rapid pace between now and 2030.

6. Better batteries

Improving batteries has always been hampered by slow experimentation and discovery processes. AI is currently being used to advance battery development and make this process faster. There's also a drive for this so we have more efficient electric vehicle batteries, a must if cars all go towards an ACES direction.

7. Improved weather prediction AI

As our climate changes, the need to predict disasters will become paramount. In 2023, scientists at the University of Texas created an AI tool that could predict earthquakes with 70% accuracy a week in advance. Expect this technology to mature in the next decade.

8. Preventative medicine

With strides in AI, doctors may be empowered to predict a patient's health issues far in advance. Preventative action will be more common, and likely encouraged by governments and health insurance providers to avoid costly treatments further down the line.

9. Real time linguistic translation

Think Google Glass, but translating other languages that you are staring at or hearing in real time. We already have AI technology where you can take a photo with your phone and translate text, but this will be a step up from that. This would be a massive benefit not only for tourists, but for business interactions in different countries.

10. Adaptive PII detection

One of the biggest issues with AI use is when people put in personally identifiable information (PII) or sensitive information in it. With adaptive PII detection, this would be nipped in the bud before it becomes a problem, which is of benefit to both the user and the service providers.

•• [Blog by Hightower](#)

Tech in 2024: The top 10 tech trends to watch closely this year

Here are the emerging trends you should expect over the next 12 months, and how it might affect you and your business.

Every year, the landscape of technology is different, and it's our job to keep on top of it. In this article, we cover the emerging trends that will shape the global landscape over the next year, and what you can expect.

If you're interested in learning about where to upskill yourself, your team, or your business, we'd also recommend checking out [Pluralsight's Year in Tech 2023](#). In it, we break down the last twelve months of tech trends to help you know where to focus your energies in 2024.

Our predictions

1. [There will be a more mature offering of AI products and services](#)
2. [The AI market leaders will start to surface](#)
3. [There will be a chatbot in nearly everything](#)
4. [We'll get more open-source and ethical AI options](#)
5. [The motto of 2024 will be "Cybersecurity or Die"](#)
6. [Organizations will suddenly be desperate to clean data](#)
7. [There will be more code translators, wider language support](#)

8. [Work will be more abstracted, more low and no-code options](#)
9. [Businesses will remember the cloud exists](#)
10. [Human intelligence will become vital for organizations](#)

1. There will be a more mature offering of AI products and services

Since ChatGPT dropped in November 2022, every tech company has been in a mad rush to integrate AI into their products, or offer it themselves. Now that people have had over a year to catch up, expect a flood of highly competitive AI offerings.

We're already starting to see it in the cloud space ([Azure and AWS are going head to head on AI](#)), but in 2024 this will extend to every conceivable field, because [AI can benefit customers in pretty much every industry](#).

Expect there to be a lot more multimodal generative AI options as every company tries to outdo each other in this area in 2024. Read our article on why things are likely [moving towards an omnimodal future](#).

2. The AI market leaders will start to surface

There will be a lot of fierce competition in 2024 as we start to get a clearer idea of who is going to wind up with market share for AI-related products and services in 2025 and beyond. Once we get to that point, it will be more difficult for newcomers to come in and compete with these more mature offerings.

3. There will be a chatbot in nearly everything

2024 will be the year of “Do you want a chatbot with that?” This is because the lowest hanging fruit for businesses will be [conversational chatbots and virtualized assistants](#). They’re the most obvious application to help with customer service, and they’re fairly easy to implement with tools like Amazon Lex and Azure AI Bot Service. Technologists who are under pressure to “start using AI” will likely start here, and expand outwards.

For consumers, this means you’ll start seeing chatbots pop up in everything in 2024, perhaps to the point you even get sick of them!

4. We’ll get more open-source and ethical AI options

Ethical consumerism is very important for Gen Z and Millennials, who prioritize social and environmental responsibility (Gen Z in particular are more risk averse). Given the choice between openly ethical AI options and

products that were created questionably, they'll likely choose the former. This will be an increasingly important market differentiator for AI companies in 2024 ([Anthropic and Claude AI](#) are ahead of the curve, here).

Many tech professionals also hate to be tied down to closed source solutions and prohibitively expensive subscriptions. As companies like Microsoft, Amazon, IBM, Nvidia, and Google try to rope in customers, there will be a counter movement of open source alternatives. Given some corporations need intimate knowledge of how ethically an AI was built and a need to have control over it, open source will definitely be in demand.

5. The motto of 2024 will be “Cybersecurity or Die”

In 2024, bad actors will be able to create cyber threats with next to no effort: people will be able to ask [chatbots to make viruses or phishing letters](#), while Generative Adversarial Networks (GANs) can be used to create [incredibly powerful malware](#). While the motto of 2023 was “AI or Die”, the motto for 2024 will be “Cybersecurity or Die.”

6. Organizations will suddenly be desperate to clean data

Expect this sentence in 2024: “We really need to clean our business data.” Rather than it being a matter of data hygiene, this will be a matter of critical

importance, since companies will be trying to get business insights from data using AI, and the insights will be only as good as the data you've got on hand.

On a low level, businesses will be inputting business data into tools like ChatGPT and processing it for quick insights with data analysis. On a bigger scale, organizations will be using tools like Amazon Q to get sophisticated insights across all their business data. Again, someone's going to have to clean it up!

7. There will be more code translators, wider language support

Ever swore about having to update the version of your code to a newer version, or wanted to switch it to a new language entirely? AI is going to be a big help here, and we've already seen things like Amazon Q that can upgrade Java 8 and Java 11 code to Java 17 code. In 2024, we'll see more support for a greater spectrum of languages, not just obvious ones like Python.

8. Work will be more abstracted, more low and no-code options

In 2023, AI was being used to abstract away tactical parts of people's roles, and there will be a whole service offering around this in 2024 onward. You've got AI-powered coding assistants like GitHub Copilot, Tabnine, and

AWS CodeWhisperer, as well as tools like [Amazon Q](#), which can provide architectural advice for your workloads.

Even making AI can be no code, with options like Azure Machine Learning Studio, which is pretty much drag and drop. We'll see more low and no-code services, more SDKs, more AI assistants for every conceivable task. In 2024, all of this will cascade into abstracting away work for non-technical roles as well, such as customer service, graphic design, finance, teaching, and more.

9. Businesses will remember the cloud exists

With all the excitement about AI (though largely justified), organizations will remember that cloud computing services are still as essential to drive customer value in 2024 as they were in 2020.

10. Human intelligence will become vital for organizations

As organizations try and capitalize on AI in 2024, they'll need people who can actually use them, [according to Pluralsight CEO Aaron Skonnard](#).

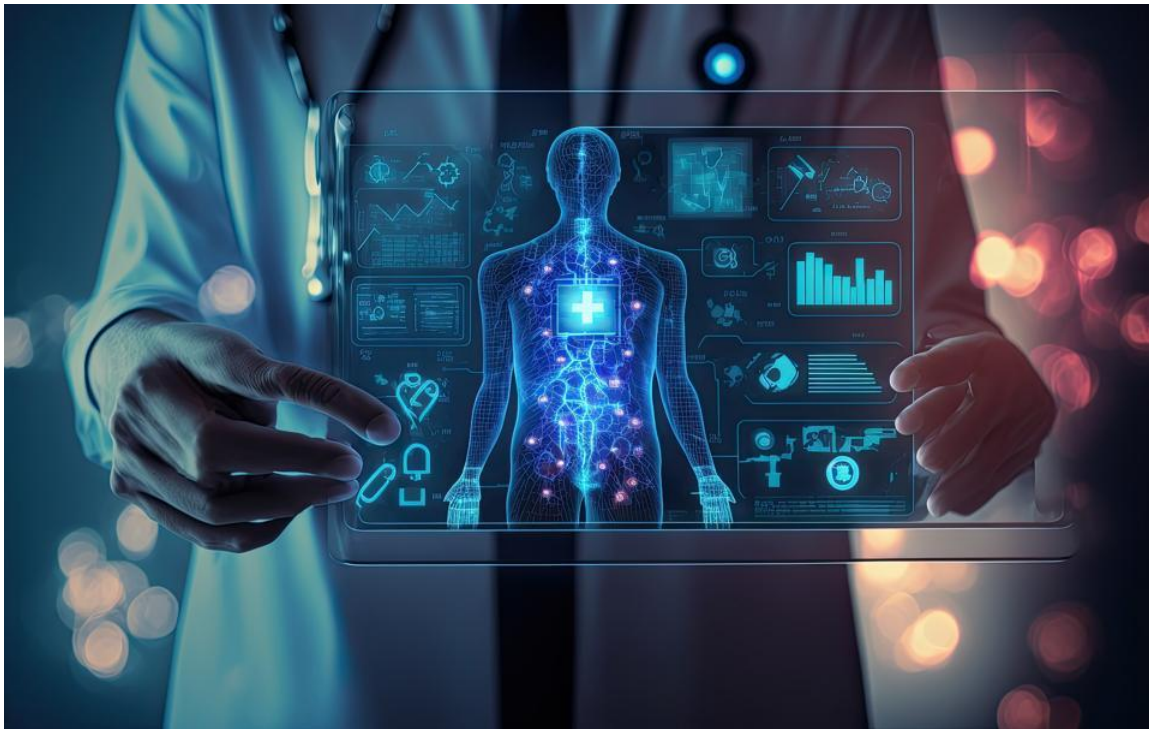
“Artificial intelligence, like any technology, still relies on human intelligence,” he said. “So if you want to get the most out of AI, you need

people with the skills to leverage that technology and who have the other skills you need important to your business.”

“It's those people will understand the benefits that AI can bring to their functions, and ultimately unlock them for your organization... It's human intelligence that will use AI to differentiate your organization, drive the real use cases of today, and uncover the transformative business applications of tomorrow.”

AI Can Now Make You Immortal – But Should It?

For as long as we've been around, human beings have fought against the inevitability of death. This struggle has given rise to religions that have dominated human culture for millennia and has been central to philosophies that have shaped our civilizations.



AI Can Now Make You Immortal – But Should It?

But might it be the case that a scientific solution to immortality is finally in sight? In recent years, [artificial intelligence \(AI\)](#) has evolved to the stage where it looks set to revolutionize every aspect of our lives. It may just be possible that it's going to change the way that we think about – and perhaps even experience – death, too.

Science fiction has given us several examples of situations – [mostly horrific](#) - where human minds can be uploaded to machines, effectively allowing us to outlast our mortal, fallible bodies.

But recent research and developments have shown that this technology might be closer than we think. Even more presently, others are attempting to preserve elements of our personality and minds so that, at least in some capacity, we can remain a part of the lives of those we leave behind.

So, let's take a look at some of the options that are – or will be – on the table for those of us with a desire to evade the reaper's blade.

Back in 2020, a Korean documentary crew worked with VR producers to allow a grieving mother to [“reunite”](#) with her dead daughter. It was a process that divided opinion, with many considering it ghoulish. However, the mother herself reported that the experience helped her through her grieving process and that she had no regrets about going through with it.

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This encounter was scripted, and although the graphics were super-realistic, the opportunity for Jang Ji-Sung to interact with the deceased seven-year-old was limited.

Just a few years later, however, another company (also South Korean) has demonstrated technology using AI that will potentially allow anyone to converse and interact with the dead as if they were in the same room (or at least, as if they were on a video call with them).

Deep Brain AI showed off its Re;Memory platform at this year's CES show. Essentially, it works by taking video footage of facial movements along with voice recordings and applying algorithms that generate new footage of whatever interactions are needed.

At the moment, it's reported that the process of creating the 3D representation of the person will cost around \$10,000, and there will then be a \$1,000 fee for an hour-long meeting. As it doesn't react in real-time, the conversation must be agreed upon in advance.

However, it seems a safe bet that in the near future this technology will converge with natural language platforms such as [ChatGPT](#), enabling us to have real-time conversations with the deceased.

The idea has certainly attracted its fair share of criticism, with some claiming that this is simply profiteering on grief or intruding into the grieving process of those that are left behind. But others agree that it's an idea that's worth considering, particularly if it helps us cope with the grieving process.

There's a chance the benefits will not end there, though – what if it can prevent valuable experience and expertise from being lost due to the inconvenient certainty of mortality?

Digital Immortality?

If he was still around, would Einstein be able to build on the advances in our knowledge of physics that have been made since he died to solve some of the problems that today's scientists are still struggling with? Would Washington or Gandhi have been able to broker a peace deal that would put an end to

conflicts the world raging around the world today? What kind of movies would Shakespeare be writing if he had not yet shuffled off this mortal coil?

There's no way of knowing, of course, because the potential of those people to do good in the world ended at the same time as the electrical activity stopped in their brains.

But some have proposed that if we capture enough data during someone's life, it might be possible to keep them around indefinitely after their physical brain has gone. This may not be as difficult as it sounds – Microsoft researchers Gordon Bell and Jim Grey have estimated that logging every conversation that a human has over their entire lifespan would only require around one terabyte of storage.

Running a “[digital twin](#)” of a deceased person would allow us to continue to benefit from their wisdom as long as it's necessary. As we've been shown possible with machine learning, there's no reason that the "person" would have to stop absorbing more knowledge and improving their understanding of the world.

Of course, the obvious extension of this line of thinking is, why wait for them to die? If we can replicate someone after death, then we can replicate them while they are still alive. We could have 10 or 100 Einsteins, all working on solving different physics problems, or an individual Shakespeare for every person on Earth, dedicated to creating personalized stories and plays to keep them entertained. Running a business and don't have enough time to spend at home with your family? No problem, set your digital twin to work, keeping your empire running while you concentrate on what's really important.

Some of these ideas are encapsulated in the concept of [digital eternity](#), an MIT research project that aims to explore the technological and philosophical requirements of creating digital twins that would effectively let us live forever.

Should We, Though?

It's worth bearing in mind that when photography and then filmmaking were new technologies, both were presented by academics and philosophers as possible solutions to the problem of mortality.

From a philosophical point of view, it's often pointed out that death has always been a natural part of life, and there's no real way of knowing what sort of effects it might have on our species and on society if we were to eliminate it. Evolution enables us to come up with new ideas as new brains emerge that are better tuned to cope with the realities of everyday life.

On the other hand, others posit that we might behave better if we knew that we are going to be around forever – or at least for a very long time – and can't expect to eventually escape the consequences of our actions through death.

One thing that's certain is that death is a problem we'll never stop trying to solve, and as new technologies like AI, digital twins, and virtual reality redefine our lives, we'll keep thinking of ways that they might also redefine our deaths.

Perhaps with some technological assistance, some of you reading this may one day live on to see what attractions the future has in store – such as the Earth being swallowed by the sun in seven billion years' time, or with the death of the universe, [far further](#) into the future.

Technological leaps could bring human immortality by 2030



Visualization of a human merging with technology© Bing Image Creator

The past few months have witnessed intense technological advancements, echoing the forecasts of Ray Kurzweil. This well-known futurist and computer scientist predicts that the coming decade will bring humanity closer to immortality, with artificial intelligence poised to pass the Turing test. Kurzweil has a track record of successful predictions in new technologies.

In 1990, Kurzweil forecasted that by 2000, computers would defeat world chess champions and herald the era of portable computers and smartphones. In 2010, he revisited his earlier predictions, finding that **out of 147 predictions, 115 fully came true, 12 partially materialized, and only three were incorrect**, one being the widespread use of autonomous cars by 2009. Now, Kurzweil asserts that in the next seven years, humanity will achieve immortality.

What will change in human life in 5 years?

In one of his articles, Kurzweil claimed that **by 2030, we will be able to extend life expectancy by more than a year each year**, potentially ending deaths from natural causes. These advancements will bring changes affecting every aspect of our world.

The futurist envisions a future where nanobots in our bloodstreams repair tissues and deliver medications directly to infection sites. Technology will enable our minds to connect to the cloud, allowing near-instantaneous transmission of thoughts, videos, or messages, and even creating backups of our memories.

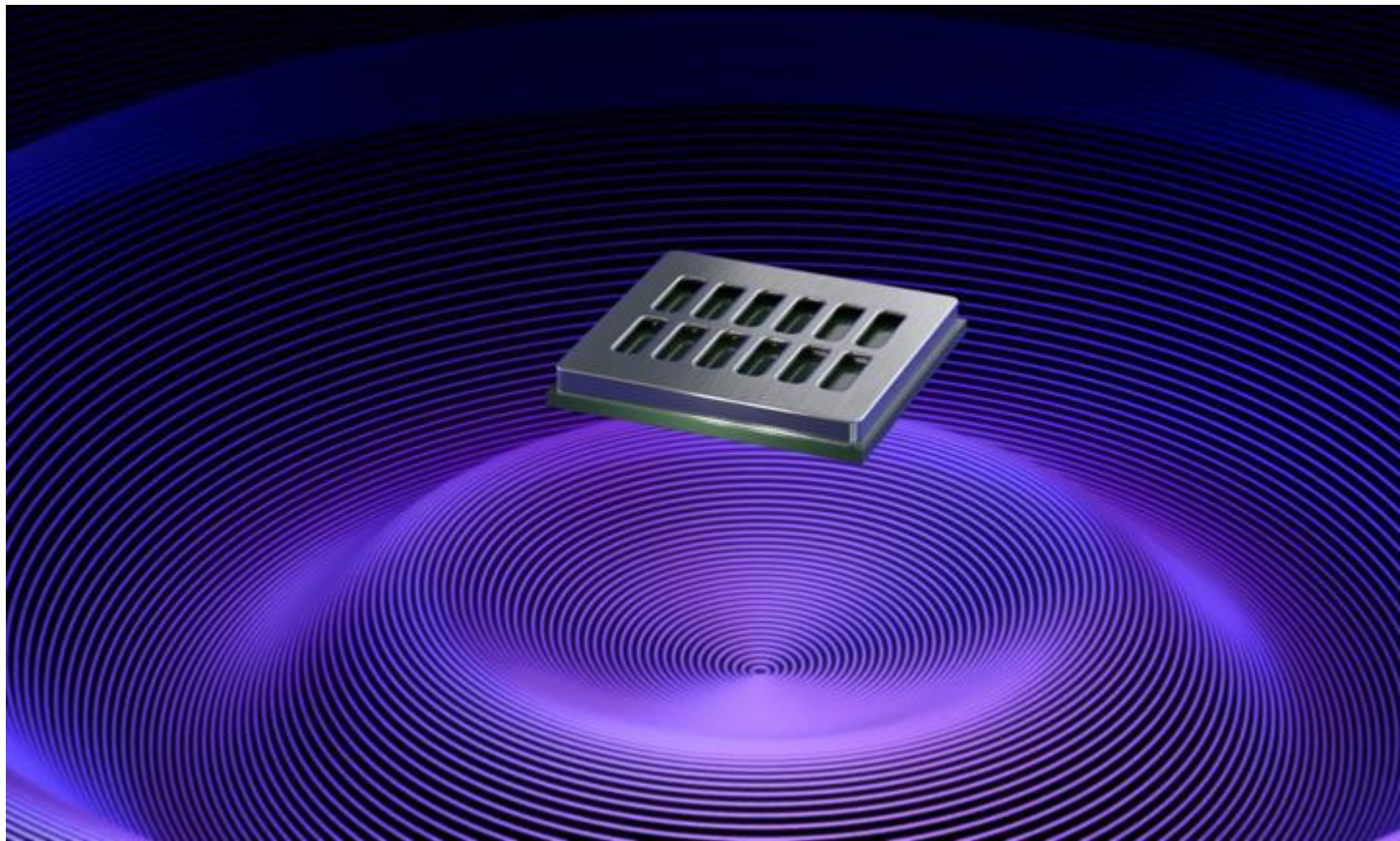
Will artificial intelligence surpass the limits of imagination?

Kurzweil identifies **the year 2045** as the point when artificial intelligence will exceed our current imaginative limits. He views this future not as dystopian, but

as an opportunity to enhance human intellect to unparalleled heights. In his opinion, AI will multiply human intelligence, leading to a state of being "godlike."

Kurzweil's conclusions are primarily based on his observation of current technological trends. For instance, he highlights the ability of paralyzed individuals to construct sentences via electrodes connected to their brains, a possibility increasingly realized through advancements by companies like Elon Musk's Neuralink. Whether these predictions will come to fruition remains to be seen in seven years.

Tiny Speaker Promises Big Sound From Smartwatches and Smart Glasses



Tiny Speaker Promises Big Sound From Smartwatches and Smart Glasses© xMEMS Labs

PCMag editors select and review products [independently](#). If you buy through affiliate links, we may earn commissions, which help support our [testing](#).

The latest micro fidelity driver from xMEMS Labs is not meant to go inside typical audio products like [earphones](#) or [headphones](#). Instead, the full-range Sycamore speaker aims to bring audio to a wide variety of wearable devices that broadcast sound near your ear rather than inside it.

The jump in quality should make such devices far better at delivering enjoyable audio experiences beginning in late 2025.

The Sycamore micro-electromechanical systems (MEMS) driver measures 8.41 by 9 by 1.13mm (HWD) and weighs 150 milligrams. It's one-seventh the size of a typical dynamic driver and one-third the thickness, xMEMS Labs says. This, in turn, reduces the area needed behind the driver to produce good sound.

It's this incredibly small size that allows it to fit inside the confines of spaces like [smartwatches](#), [smart glasses](#), and other wearables. The "membrane" that moves is made from silicon rather than a more fluid material like paper or rubber, and it is much more rugged, earning an [IP58 rating](#) for protection from sweat or rain—a key feature for devices meant to be worn.

(Credit: xMEMS Labs)

Despite its small size, xMEMS' Sycamore doesn't skimp on performance; the driver covers a full range of audio, including sub-bass, mid-bass, and high frequencies, xMEMS Labs claims. It can do so at surprisingly high volumes, which allows it to push sound across the air between the device and the wearer's ear.

Target devices include open wireless earbuds, XR headsets, and more. "The applications for Sycamore...are limited only by designers' imagination," xMEMS Labs says.

Sampling for the Sycamore begins in early 2025, with full production slated to start in October.

New fanless cooling technology enhances energy efficiency for AI workloads by achieving a 90% reduction in cooling power consumption



New fanless cooling technology enhances energy efficiency for AI workloads by achieving a 90% reduction in cooling power consumption© Shutterstock.com / Gorodenkoff

- **New HPE fanless cooler cuts server blade power consumption by 37%**
- **The system uses direct liquid cooling, perfect for AI technologies**
- **The architecture is designed to be scalable dependent on business needs**

Hewlett-Packard Enterprise (HPE) recently hosted its AI Day 2024 event, introducing the industry's first 100% fanless direct liquid cooling architecture.

As artificial intelligence ([AI](#)) technologies continue to evolve, power consumption in next-generation accelerators has increased, surpassing the capabilities of traditional air-cooling methods.

Organizations running large-scale AI workloads are now searching for more efficient solutions to manage their infrastructure's energy demands, and HPE has pioneered direct liquid cooling technology, which has become one of the most effective methods for cooling high-performance AI systems. This approach has allowed HPE to deliver seven of the top 10 most energy-efficient supercomputers on the Green500 list.

100% fanless direct liquid cooling addresses cooling challenges in AI systems

The new cooling system is designed to improve efficiency in several key areas, with [HPE](#) saying the fanless architecture reduces cooling power consumption by 90% compared to traditional air-cooling systems and offers significant environmental and financial advantages.

The system is built on four core elements. First, the system uses a comprehensive cooling design featuring an 8-element system that cools the GPU, CPU, server blade, local storage, network fabric, rack, cluster, and coolant distribution unit (CDU).

The second element is that the fanless cooler also offers high-density performance that supports compact configurations backed by rigorous testing, monitoring software, and on-site services to ensure smooth deployment.

Thirdly, for those with a mind for the environment, the new system uses an integrated network fabric that enables large-scale connectivity with reduced costs and power consumption for a more sustainable architecture. Lastly, the architecture runs on an open system design that offers flexibility by supporting

various accelerators, allowing organizations to select solutions that best suit their needs.

The fanless architecture reduces cooling power consumption by 37% per server blade compared to hybrid liquid-cooled systems, not only lowering utility costs but also reducing carbon emissions and eliminating data center fan noise. Furthermore, the design allows for higher server cabinet density, helping organizations cut floor space requirements in half.

"As organizations embrace the possibilities created by generative AI, they also must advance sustainability goals, combat escalating power requirements, and lower operational costs," noted Antonio Neri, President and CEO of HPE.

"The architecture we unveiled today uses only liquid cooling, delivering greater energy and cost-efficiency advantages than the alternative solutions on the market. In fact, this direct liquid cooling architecture yields 90% reduction in cooling power consumption as compared to traditional air-cooled systems."

Supermicro to help Musk scale xAI supercomputer to a million GPUs — Supermicro will set up local operations in Memphis to facilitate operations



Supermicro to help Musk scale xAI supercomputer to a million GPUs — Supermicro will set up local operations in Memphis to facilitate operations© Charles Liang

Supermicro CEO Charles Liang announced on [X \(formerly Twitter\)](#) that he will set up shop near xAI's Colossus AI supercomputer to help Musk achieve his dream of one million GPUs. Liang said that he plans to establish "local operations/production, validation, service and support." Although it has been previously reported that [Elon Musk shifted \\$6 billion worth of AI server orders](#) from Supermicro to its competitors because of [its financial problems](#), it seems xAI still plans to order from the beleaguered server supplier.

While Nvidia is likely the biggest winner behind Musk's planned one million GPUs, which will most probably be powered by a mix of Hopper and Blackwell GPUs, it will also require all the accouterments needed to run a complete supercomputer. This includes servers and liquid-cooling solutions, which Supermicro is known for building. And with such a massive order, it does make sense for Liang and his company to put up local operations to support Musk's '[Gigafactory of Compute](#)'.

Supermicro is here to support xAI's massive 10-fold expansion of the Colossus supercomputer in Memphis with over 1 million GPUs by establishing local operations/production, validation, service and support. With our optimized datacenter building blocks (DCBBS) and ambient...December 5, 2024

This move will benefit xAI's operations, as Supermicro would be able to deliver its products and services to such a massive AI server with much greater efficiency. But aside from that, it would also mean that the company would invest millions, if not billions, of dollars in Memphis and the surrounding area to get its operations up and running in support of the Colossus AI supercomputer.

An investment of this scale would greatly benefit the city and the state of Tennessee, bringing in a lot of money in investments and likely creating several thousand new jobs, both directly and indirectly. However, some of the surrounding communities are also concerned about the negative impact of having such a power-hungry industry setting up shop in their area.

Some experts estimate that the 100,000 H100 GPUs Musk currently has in his Memphis facility need 155MW to run. While it already has approval from the Tennessee Valley Authority (TVA) to receive 150MW, some community members are concerned that this huge demand will cause energy prices to spike for residential consumers and that the quick solution to this problem would be to build a new gas plant.

After all, if Musk brings an additional 900,000 GPUs online in the coming years, then his AI facility would likely require over 1.5GW of power. And if other corporations, like Supermicro, set up shop locally, they would need power, too, thus putting a lot of strain on the local electricity supply grid.

The massive power requirements of AI training have pushed several tech companies to invest in nuclear power. [Amazon](#), [Google](#), [Microsoft](#), and [Oracle](#) have already signed contracts to develop small modular reactors or restart old large nuclear plants. Even [Meta](#) is getting in on the action, having recently released a request for proposals. However, it seems that Elon hasn't made any plans to invest in nuclear power just yet.

This development is good news for the labor force in Memphis and the state of Tennessee, especially as it has the potential to bring in new jobs and investments in the state and city. However, it must also consider the impact of such a power-hungry industry entering the area.

Dell Joins AI Race, Deploys GPUs for Musk's Supercomputer Project in Memphis

Dell Technologies has secured a significant share of the AI chip server [market](#) by distributing graphics processing units (GPUs).

On Thursday, the company announced deploying tens of thousands of GPUs to support AI operations at Elon Musk's [supercomputer](#) project in Memphis.

Jeff Clarke, Dell Technologies' Chief Operating Officer, highlighted the company's success in deploying GPUs at scale within just a few months. He mentioned that the cluster is still under construction and emphasized how Dell differentiates itself.

While Clarke did not specify Dell's share of servers or infrastructure contributing to the project, he emphasized that the company aims to secure a fair market share.

Musk's startup, xAI, is developing large-scale facilities to boost computing power and accelerate the development of AI-based tools.

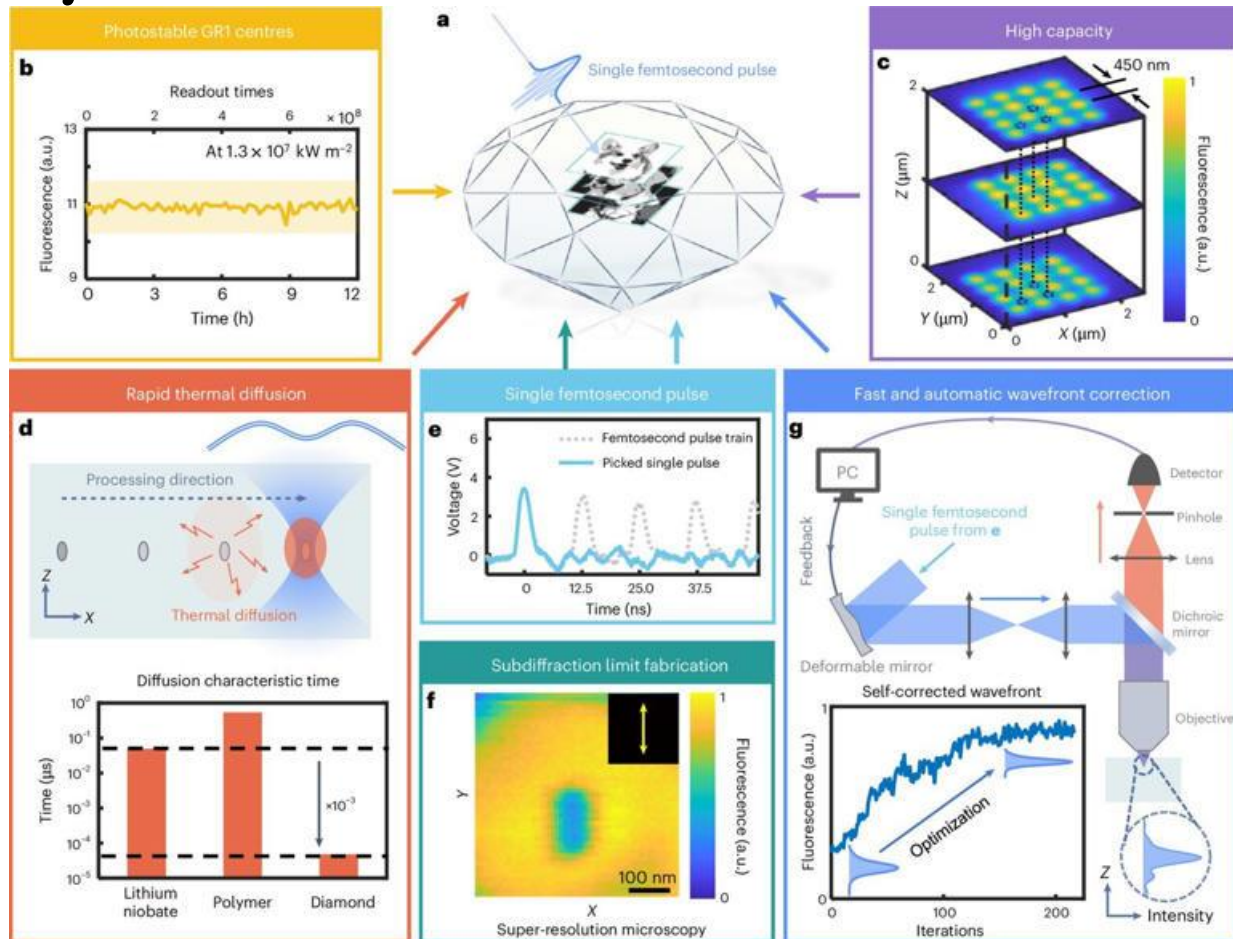
The Greater Memphis Chamber announced the previous day that [NVIDIA](#), Dell Technologies, and Super Micro Computer will collaborate on this project, which will house at least 1 million GPUs.

Dell Technologies is experiencing strong growth this year, driven by demand for high-performance servers equipped with NVIDIA GPUs essential for running AI workloads.

For the quarter ending November 1, Dell shipped \$2.9 billion worth of AI-centric servers.

Despite this growth, Dell Technologies' stock price closed at \$125.41, reflecting a slight decline of less than 1%.

Higher-density storage technique could allow diamond disk to store equivalent of 2,000 Blu-ray discs



The concept of diamond storage medium. Credit: Nature Photonics (2024). DOI: 10.1038/s41566-024-01573-1

A team of engineers at the University of Science and Technology of China has developed a new way to code data onto a diamond with higher density than prior methods. In their paper [published](#) in the journal *Nature Photonics*, the group notes that such optical discs could hold data safely at room temperature for millions of years.

Prior research has shown that it is possible to code data onto a diamond, allowing for much longer data storage than any other known method. But such

efforts have produced low-density storage. In this new effort, the research team developed a new method for etching data onto a diamond that allows for much denser data storage, and thus for storing more information onto a single diamond.

In their work, the researchers used diamond pieces just a few millimeters in length—they were pursuing a proof of concept, not a true storage medium. Future versions, they note, could be the size of a Blu-ray disc. The new method involved the use of a laser to remove single carbon atoms from the surface of the diamond, leaving a tiny cavity. The cavity, the researchers note, exhibits a certain level of brightness when another laser is shone on it.

The researchers found that by controlling the energy levels of the writing laser, they could control the degree of brightness of a given site on the diamond by removing certain numbers of atoms. In this way, data can be stored as empty spaces with various brightness levels. A reader laser could then be used to determine the brightness level of a given site, and use that to decode the information.

The research team tested their idea by coding stored images onto a tiny diamond chip and found their method was 99% accurate. They acknowledge that their method is not currently economically viable, however, due to the high cost of the laser, but suggest it could be used for certain high-importance applications.

More information: Jingyang Zhou et al, Terabit-scale high-fidelity diamond data storage, *Nature Photonics* (2024). [DOI: 10.1038/s41566-024-01573-1](https://doi.org/10.1038/s41566-024-01573-1)

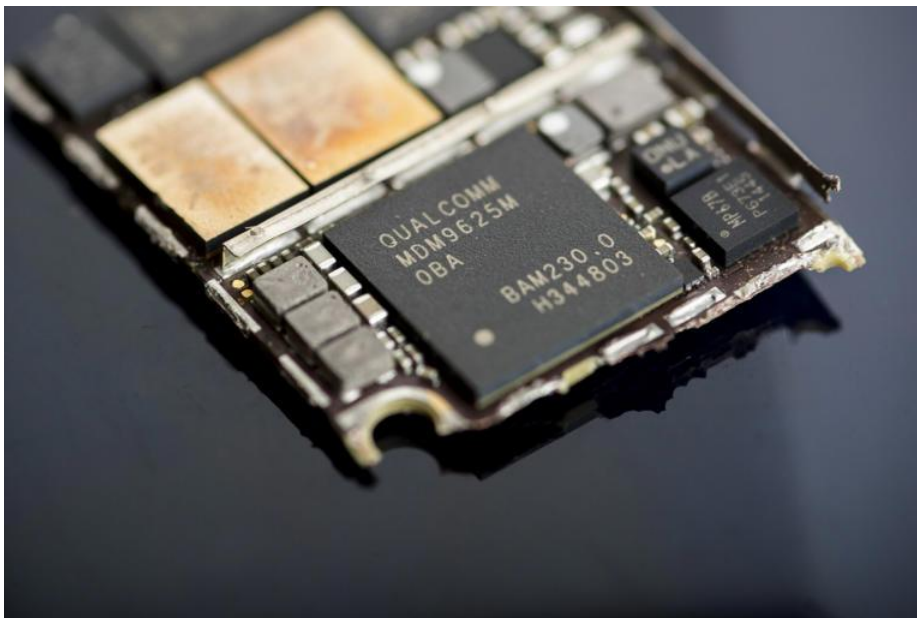
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Apple Plans Three-Year Modem Rollout in Bid to Top Qualcomm

(Bloomberg) -- Apple Inc. is preparing to finally bring one of its most ambitious projects to market: a series of cellular modem chips that will replace components from longtime partner — and adversary — Qualcomm Inc.

More than half a decade in the making, Apple's in-house modem system will debut next spring, according to people familiar with the matter. The technology is slated to be part of the iPhone SE, the company's entry-level smartphone, which will be [updated next year](#) for the first time since 2022.

A modem is a critical piece of any mobile phone, letting the device connect to cell towers in order to make calls and link up with the internet. Apple's first version of the component will be followed by further generations that become increasingly more advanced. The company hopes to ultimately overtake Qualcomm's technology by 2027, said the people, who asked not to be identified because the project is confidential.



Inside An Apple Inc. iPhone 6 Smartphone© Photographer: Brent Lewin/Bloomberg

Apple's modem has been a long time coming. When the company set out to build the chip, it originally hoped to bring it to market as early as 2021. To jump-start the effort, the company invested billions of dollars to set up testing and engineering labs around the world. It also [spent about \\$1 billion](#) to acquire Intel

Corp.'s modem group and millions more hiring engineers from other silicon companies.

Over the years, Apple encountered setback after setback. Early prototypes were too large, ran too hot and weren't power-efficient enough. There also were concerns internally that Apple was simply developing a modem to get back at Qualcomm, following a legal battle over licensing payments that didn't go the iPhone maker's way.

But after adjusting development practices, reorganizing management and hiring scores of new engineers from Qualcomm itself, Apple is now confident that its modem plan will work, the people said. It would be a major win for the company's hardware technologies team, which is run by Senior Vice President Johny Srouji.

Representatives for Apple and Qualcomm declined to comment.

Qualcomm has long been preparing for Apple to switch away from its modems, but the company still receives more than 20% of its revenue from the iPhone maker, according to data compiled by Bloomberg. Its stock fell as much as 2% to a session low after Bloomberg News reported on Apple's plans Friday.

Shares of Qorvo Inc., another component supplier at risk of being replaced by Apple's modem efforts, declined as much as 6%. Apple shares were little changed as 12:52 p.m. in New York.

When the iPhone SE debuts in a few months, it will have major new features, including Apple Intelligence and the edge-to-edge screen design already used in more upscale models. But its most impressive breakthrough won't be visible to consumers: the in-house modem, code-named Sinope.

For now, the modem won't be used in Apple's higher-end products. It's set to come to a new mid-tier iPhone later next year, code-named D23, that features a far-thinner design than current models. The chip will also start rolling out as early as 2025 in Apple's lower-end iPads.

In preparation for the iPhone SE, Cupertino, California-based Apple has been secretly testing the new modem on hundreds of devices deployed to employees

globally. And it has been doing quality assurance testing with its carrier partners around the world.

The company decided to start with lower-end products in part because a modem is a risky endeavor: If it doesn't work properly, customers will suffer dropped calls and missed notifications. There's little tolerance for that on Apple's highest-end, \$1,000-plus iPhones.

Moreover, Sinope isn't as advanced as the latest modems from San Diego-based Qualcomm, meaning the first Apple modem is a downgrade from the component currently in the iPhone 16 Pro.

Unlike today's high-end Qualcomm parts, the Sinope modem won't support mmWave, a type of 5G technology used by Verizon Wireless and other carriers, primarily in major cities, that can theoretically handle download speeds of as much as 10 gigabits per second. Instead, the Apple component will rely on the Sub-6 standard, a more prevalent technology used by the current iPhone SE.

The first Apple modem will also only support four-carrier aggregation, a technology that combines bands from several wireless providers simultaneously to increase network capacity and speeds. Modems from Qualcomm can support six or more carriers at the same time.

In lab tests, the first Apple modem caps out at download speeds of about 4 gigabits per second, less than the top speeds offered by non-mmWave Qualcomm modems, the people said. Real world speeds for both types of modems are typically far less, meaning that customers might not notice a difference in day-to-day use.

In any case, the first Apple modem will have several other advantages that the company believes will give it an edge with consumers. For one, it will be tightly integrated with Apple-designed main processors to use less power, scan for cellular service more efficiently and better support on-device features for connecting to satellite networks.

The Apple modem will also be able to offer better performance relative to SAR limits because it will be managed intelligently via the main processor, the people said. SAR, or specific absorption rate, is a measure of the radio frequency

absorbed by the body, and government agencies such as the US Federal Communications Commission regulate [acceptable levels](#).

Apple is also planning to include support for DSDS, or dual SIM dual standby. That allows data connections on both SIM cards when a user is using two phone numbers for their device.

The new modem will be produced by Taiwan Semiconductor Manufacturing Co., the manufacturer of the main processors inside the iPhone, iPad, Mac and other Apple devices.

To help build its modem, Apple rapidly expanded its office space in San Diego and other parts of Southern California, looking to poach talent from Qualcomm. Executives involved in the modem's development believe that some of the resources and talent acquired from Intel in 2019 were inadequate, and that hiring from Qualcomm helped Apple overcome earlier setbacks.

Some of the development work for the modems has also taken place in Cupertino and offices in Munich.

The modem will work with another new Apple component: a radio frequency front-end system, or RFFE, called Carpo that helps devices connect to cellular networks.

That part will also take away business from Qualcomm, and could eventually affect Qorvo as well. Today, Apple uses Skyworks Solutions Inc. and Broadcom Inc. for so-called RF filters — relationships that will continue. Apple and Broadcom extended their supply agreement in 2023.

Shares of Broadcom gained as much as 4.9%, while Skyworks climbed up to 2.6%.

In 2026, Apple looks to get closer to Qualcomm's capabilities with its second-generation modem, which will start appearing in higher-end products. This chip, Ganymede, is expected to go into the iPhone 18 line that year, as well as upscale iPads by 2027

The big difference is that Ganymede will catch up to current Qualcomm modems by adding support for mmWave, download speeds of 6 gigabits per second, six-carrier aggregation when using Sub-6, and eight-carrier aggregation when using mmWave.

In 2027, Apple aims to roll out its third modem, code-named Prometheus. The company hopes to top Qualcomm with that component's performance and artificial intelligence features by that point. It will also build in support for next-generation satellite networks.

Further out, Apple is discussing merging its modem and main processor into a single component.

Google's new quantum chip has solved a problem the best supercomputer would have taken a quadrillion times the age of the universe to crack

Google scientists have created a new quantum processor that, in five minutes, cracked a problem that would have taken the world's best supercomputer 10 septillion years to solve. The breakthrough will allow quantum computers to become less error-prone the bigger they get, achieving a milestone that overcomes a decades-long obstacle.

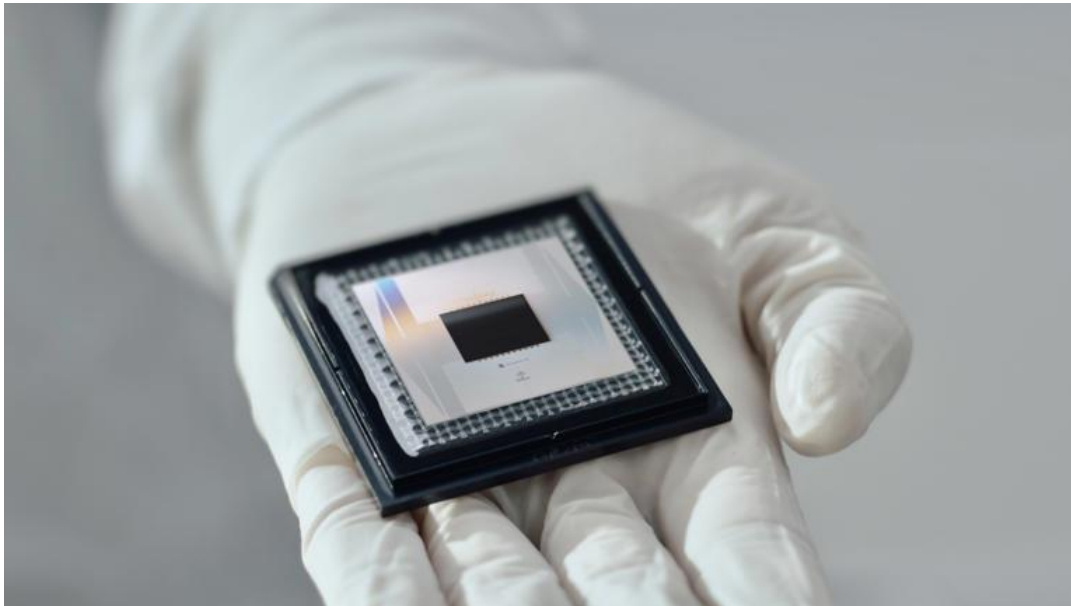
[Quantum computers](#) are inherently "noisy," meaning that, without error-correction technologies, every one in 1,000 [qubits](#) — the fundamental building blocks of a quantum computer — fails.

It also means coherence times (how long the qubits can remain in a superposition so they can process calculations in parallel) remain short. By contrast, every [one in 1 billion billion bits fails in conventional computers](#).

This high error rate is one of the key barriers to scaling up these machines so they are good enough to perform far better than the fastest supercomputers. This is why research has centered on building quantum computers with better and less error-prone — not simply more — qubits.

Google says its new [quantum processing unit \(QPU\)](#), dubbed "Willow," is the first in the world to achieve results that are "below threshold" — a milestone outlined by computer scientist [Peter Shor](#) in a [1995 paper](#). The team outlined the technology in a study published Dec. 9 in the journal [Nature](#).

Cracking a problem set decades ago



The new "Willow" quantum processor is fitted with 105 physical qubits combined with error-correcting technologies that mean the more qubits you add, the more reliable quantum computers can be. (Image credit: Google Quantum AI)

The breakthrough — achieving this "below threshold" milestone — means that errors in a quantum computer will reduce exponentially as you add more physical [qubits](#). It charts a path for scaling up quantum machines in the future.

The technology relies on logical qubits. This is a qubit encoded using a collection of physical qubits in a lattice formation. All the physical qubits in a single logical qubit share the same data, meaning if any qubits fail, calculations continue because the information can still be found within the logical qubit.

The Google scientists built sufficiently reliable qubits for exponential error reduction by making several shifts. They improved calibration protocols, improved machine learning techniques to identify errors, and improved device

fabrication methods. Most importantly, they improved coherence times while retaining the ability to tune physical qubits to get the best performance.

Related: [Monster 4,400-qubit quantum processor is '25,000 times faster' than its predecessor](#)

"What we've been able to do in quantum error correction is a really important milestone — for the scientific community and for the future of quantum computing — which is [to] show that we can make a system that operates below the quantum error correction threshold," [Julian Kelly](#), Google Quantum AI's director of quantum hardware, told Live Science.

This challenging task requires removing more errors from a system than are introduced. Below this threshold, scientists can scale up a quantum computer to be larger and larger, and errors will continue to decline, Kelly explained.

"This has been an outstanding challenge for 30 years — since the idea of quantum error correction was conceived of in the mid-90s," Kelly said.

Mind-boggling results for quantum computing

The Google researchers tested Willow against the random circuit sampling (RCS) benchmark, which is now a standard metric for assessing quantum computing chips. In these tests, Willow performed a computation in under five minutes that would have taken [today's fastest supercomputers](#) 10 septillion years. This is close to a quadrillion times longer than the age of the universe.

The first edition of the Willow QPU can also achieve a coherence time of nearly 100 microseconds — which is five times better than the showing from Google's previous Sycamore chip.

Google first announced that [Sycamore had passed the RCS benchmark in 2019](#), when scientists used the chip to resolve a problem that would have taken a classical supercomputer 10,000 years to calculate. In July, a new quantum computer built by Quantinuum [broke that record by 100 times](#).



Google first tested their Sycamore quantum computer against the RCS benchmark in 2019, and processed a calculation that would have taken a supercomputer tens of thousands of years to do. (Image credit: Google Quantum AI)

Then, in October, Google again announced that it had [discovered a new "quantum phase"](#) when using Sycamore to process calculations, meaning the best QPUs today can outperform the fastest supercomputers in practical applications for the first time.

"Coherence times are now much higher than they used to be, and we immediately translate into basically lowering all the physical operation error rates by about a factor of two," Kelly said.

"So all the underlying qubits just got better at everything they do by about a factor of two. If you look at the logical error rate between this new processor and Sycamore, there's about a factor of 20 difference — and that comes from scaling up but also pushing below threshold."

Looking beyond "below threshold"

Google scientists are now aiming to demonstrate [useful and practical computations](#) for today's quantum chips, rather than relying on benchmarking.

In the past, the team has performed simulations of quantum systems that have led to scientific discoveries and breakthroughs, Kelly told Live Science.

One example includes discovering deviations from the assumed laws of physics. But these results were still within reach of the most powerful classical computers.

Next, the team wants to create a "very, very good logical qubit" with an error rate of one in 1 million. To build this, they would need to stitch together 1,457 physical qubits, they said.

This realm is challenging because it's impossible to get there using just physical hardware — you would need error-correction technology layered on top. The scientists then want to connect logical qubits together to perform better than supercomputers in benchmarking as well as real-world scenarios.

Google unveils ‘mindboggling’ quantum computing chip



Dr Erik Lucero, lead engineer of Google Quantum AI, points to motherboards while leading media on a tour of the Quantum Computing Lab in September 2022. Photograph: Frederic J Brown/AFP/Getty Images© Photograph: Frederic J Brown/AFP/Getty Images

It measures just 4cm squared but it possesses almost inconceivable speed.

Google has built a computing chip that takes just five minutes to complete tasks that would take 10,000,000,000,000,000,000,000,000 years for some of the world's fastest conventional computers to complete.

That's 10 septillion years, a number that far exceeds the age of our known universe and has the scientists behind the latest quantum computing breakthrough reaching for a distinctly non-technical term: "mindboggling".

The new chip, called Willow and made in the California beach town of Santa Barbara, is about the dimensions of an After Eight mint, and could supercharge the creation of new drugs by greatly speeding up the experimental phase of development.

Reports of its performance follow a flurry of results since 2021 that suggest we are only about five years away from quantum computing becoming powerful enough to start transforming humankind's capabilities to research and develop new materials from drugs to batteries, one independent UK expert said. Governments around the world are [pouring](#) tens of billions of dollars into research.

Significantly, Willow is claimed to be far less prone to error than previous versions and could swell the potential of the already fast-developing field of artificial intelligence.

Quantum computing – which harnesses the discovery that matter can exist in multiple states at once – is predicted to have the power to carry out far bigger calculations than previously possible and so hasten the creation of nuclear fusion reactors and accelerate the impact of artificial intelligence, notably in medical science. For example, it could allow MRI scans to be read in atom-level detail, unlocking new caches of data about human bodies and disease for AI to process, Google said.

But there are also fears that without guardrails, the technology has the power to crack even the most sophisticated encryption, undermining computer security.

Google Quantum AI is one of numerous groups wrestling with how to harness the computing power of quantum mechanics including [Microsoft](#), [Harvard](#) University and [Quantinuum](#), a firm with UK links. A key problem is reducing the fragility of quantum chips as even microscopic

material defects, cosmic rays and ionising radiation tend to knock them off course.

"Quantum processors are peeling away at a double exponential rate and will continue to vastly outperform classical computers as we scale up," said Hartmut Neven, the founder of the firm, who said that the latest test results, published on Monday in Nature magazine, "cracks a key challenge in quantum error correction that the field has pursued for almost 30 years".

He said the far greater speed of the new chip than classical computers "lends credence to the notion that quantum computation occurs in many parallel universes, in line with the idea that we live in a multiverse".

Simply put, if a quantum computer can be in many different states at once, it can get more done at the same time.

Dr Peter Leek, research fellow at the University of Oxford's Quantum Institute and founder of Oxford Quantum Circuits, said: "It's definitely thought-provoking to put it that way. What it really does is show that quantum computing technology is rapidly moving forward. It really is working."

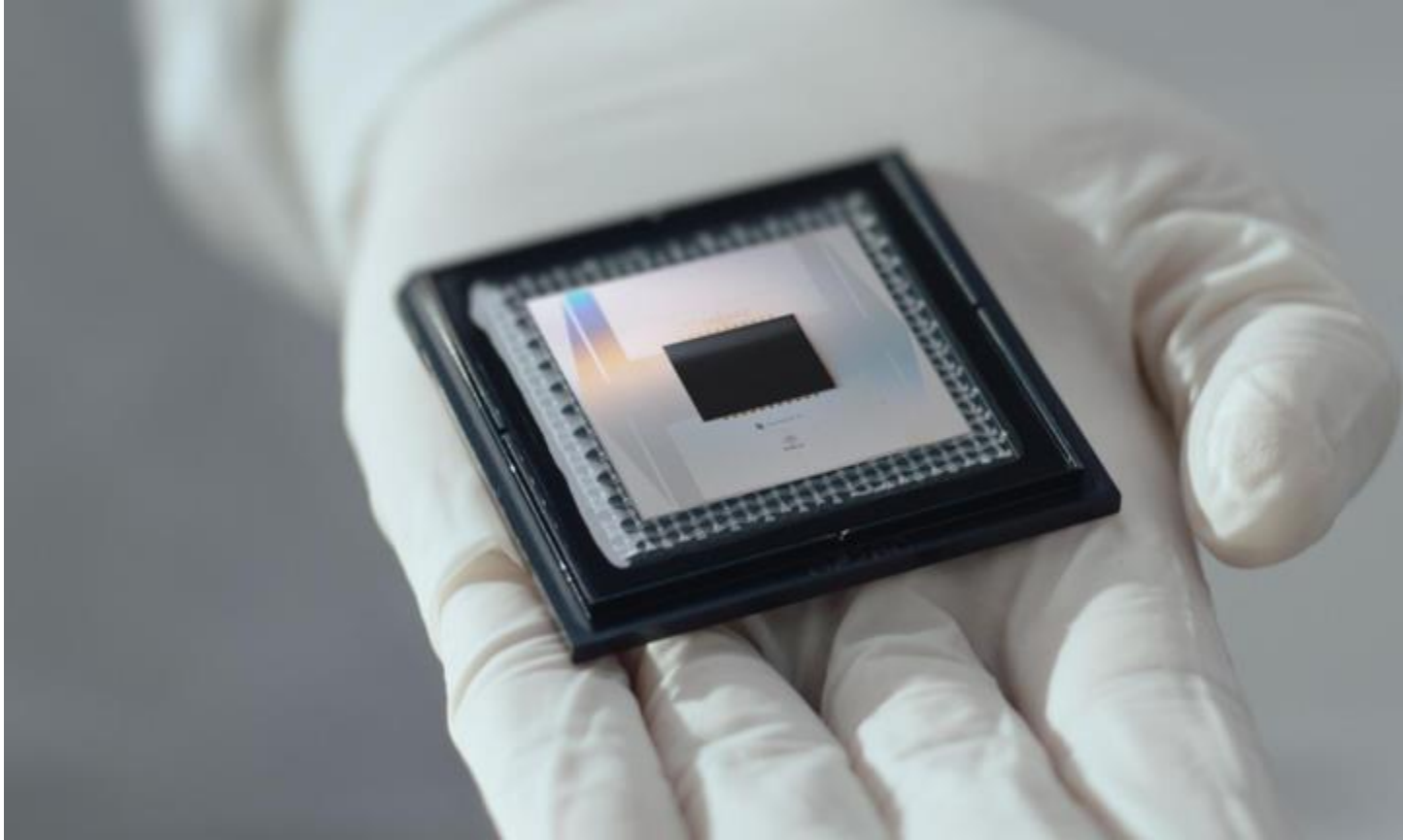
He described the Google results as a "shining example" of improvements in error correction, but he cautioned that the very fast processing results related to calculations that were "not of much real-world use".

"I'm very optimistic," he said. "I think we're going to see a real acceleration over the next five years and then we'll be able to say, look, this machine has calculated an interesting thing that I can explain to someone, and how it could be used in the real world."

Asked about the risks of high-powered quantum computers wrecking current systems of encryption, Charina Chou, the director and chief operating officer of Google Quantum AI, said: "Security experts have been working on this, and they've had ample time over the last many years to really figure out what the right standards should be, what post-quantum encryption should look like."

She added: "We're working with a number of both large companies, as well as academics and startups in this space, right of physics, of chemistry, material science that seems very, very ripe for collaboration."

Google's new quantum chip 'Willow' beats supercomputers by 10 septillion years



Google's new quantum chip 'Willow' beats supercomputers by 10 septillion years

In a stunning display of computational power, Google's latest 105-qubit 'Willow' quantum chip has outpaced the world's most sophisticated supercomputers. 'Willow' solved in minutes what would take the [fastest supercomputers](#) over a quadrillion lifetimes of the universe to figure out.

Additionally, the advanced chip showcases an exceptional ability to manage quantum noise, significantly reducing error rates as the system expands. This vital development improves the fidelity of quantum calculations and makes it possible to tackle larger, more complex problems with unprecedented accuracy.

Despite these achievements, [experts note](#) that Willow remains in the experimental phase, with the full spectrum of its capabilities yet to unfold in tackling real-world applications.

Major breakthroughs with Willow

Exponential reduction in error rates

Willow, [Google's latest quantum chip](#), is a major leap in addressing one of the intrinsic challenges of quantum computing, the issue of error rates. As quantum systems scale, the number of qubits increases, typically heightening the probability of errors, which can disrupt the accuracy of computations.

[Quantum computers](#) are inherently "noisy," meaning that without advanced error-correction technologies, every one in 1,000 qubits, the fundamental building blocks of a quantum computer, fails. This noise significantly limits how long qubits can remain in a superposition state, which is crucial for parallel processing calculations.

However, Willow has demonstrated an ability to exponentially reduce error rates by adding more qubits. This breakthrough has been achieved through advanced quantum error correction techniques, which allow the system to handle larger arrays of qubits from a 3×3 grid to a 5×5 and, finally, a 7×7 grid while continually halving the error rate with each increase in scale. By contrast, in conventional computing, every one in 1 billion billion bits fails.

This achievement overcomes a barrier that has persisted since quantum error correction was conceptualized by Peter Shor in 1995 and makes quantum computers less error-prone as they scale up.

Performance on RCS benchmark

Willow's efficacy is dramatically highlighted by its performance on the Random Circuit Sampling (RCS) benchmark, a pivotal test for quantum computing capabilities. This benchmark is one of the most challenging for quantum processors and serves as a litmus test to determine whether quantum systems can outperform classical computers on specific tasks. RCS measures if a quantum computer can solve infeasible problems for classical systems, setting a high bar for genuine quantum superiority.

In a recent demonstration, Willow completed a computation in less than five minutes that, based on conservative estimates, would take one of today's most advanced classical supercomputers, [Frontier](#), about 10 septillion years to solve. To put this into perspective, that time—10,000,000,000,000,000,000,000,000 years—far exceeds the current estimated age of the universe, underscoring the profound speed at which quantum computing can operate.

Hartmut Neven, Founder and Lead of Google Quantum AI reflected on this achievement, stating, "It lends credence to the notion that quantum computation occurs in many parallel universes, in line with the idea that we live in a multiverse, a prediction first made by David Deutsch."

Moreover, Google's use of RCS to track progress from one chip generation to the next, including previous assessments like the Sycamore results from 2019 and 2024, indicates a significant and accelerating departure from classical computing capabilities.

The making of Willow

Willow, Google's advanced quantum chip, was crafted at a state-of-the-art fabrication facility in Santa Barbara, specifically designed for quantum technology. This facility is among a select few worldwide, purpose-built from the ground up to handle the unique challenges of quantum chip production.

The engineering of Willow was a holistic endeavor involving the precise integration of various quantum components. Key elements such as single and two-qubit gates, qubit resets, and readouts were seamlessly combined to ensure

optimal performance. These components' success in harmony is crucial, while any lag or misalignment can significantly impact the overall system performance.

In the quest for quantum superiority, Google has emphasized quality over quantity. Willow boasts 105 qubits, but the quality of each qubit sets it apart, evident in its performance across rigorous benchmarks like quantum error correction and random circuit sampling. These benchmarks are vital for assessing the chip's overall performance and have demonstrated Willow's top-tier capabilities.

Notably, Willow has remarkably improved T1 times—measuring how long qubits retain excitation, a critical quantum computing resource. Achieving T1 times approaching 100 microseconds represents approximately a fivefold improvement over previous generations, underlining significant advancements in qubit stability and longevity.

Future prospects and challenges

Bridging theory and practical application

Looking ahead, the challenge for Google and the quantum computing community is transitioning from demonstrating theoretical capabilities to performing computations with tangible real-world applications. Willow aims to achieve the first “useful, beyond-classical” computation that addresses practical problems.

While RCS benchmarks and quantum system simulations have demonstrated the potential of quantum computing, they have yet to yield results that directly translate into commercial applications. Google's goal is to merge these two strands, achieving scientifically significant simulations and developing algorithms that can solve commercially relevant, complex problems currently beyond the reach of classical computers.

Invitation to collaborate

Google invites researchers, engineers, and developers to join this pioneering journey. Google fosters a collaborative environment through initiatives like open-

source software and educational courses on platforms like Coursera. These resources are designed to educate upcoming talents on quantum error correction and algorithm development, further pushing the boundaries of what quantum computing can achieve.

As Google continues to refine Willow and develop future generations of quantum chips, the focus remains on overcoming the inherent challenges of quantum computing to unlock a wide range of applications across AI, medicine, and beyond. This journey represents a collaborative effort to transform theoretical [quantum mechanics](#) into technology that can revolutionize industries and change our understanding of computation and the universe itself.

Controlling polaritons at room temperature paves the way for high-speed computing

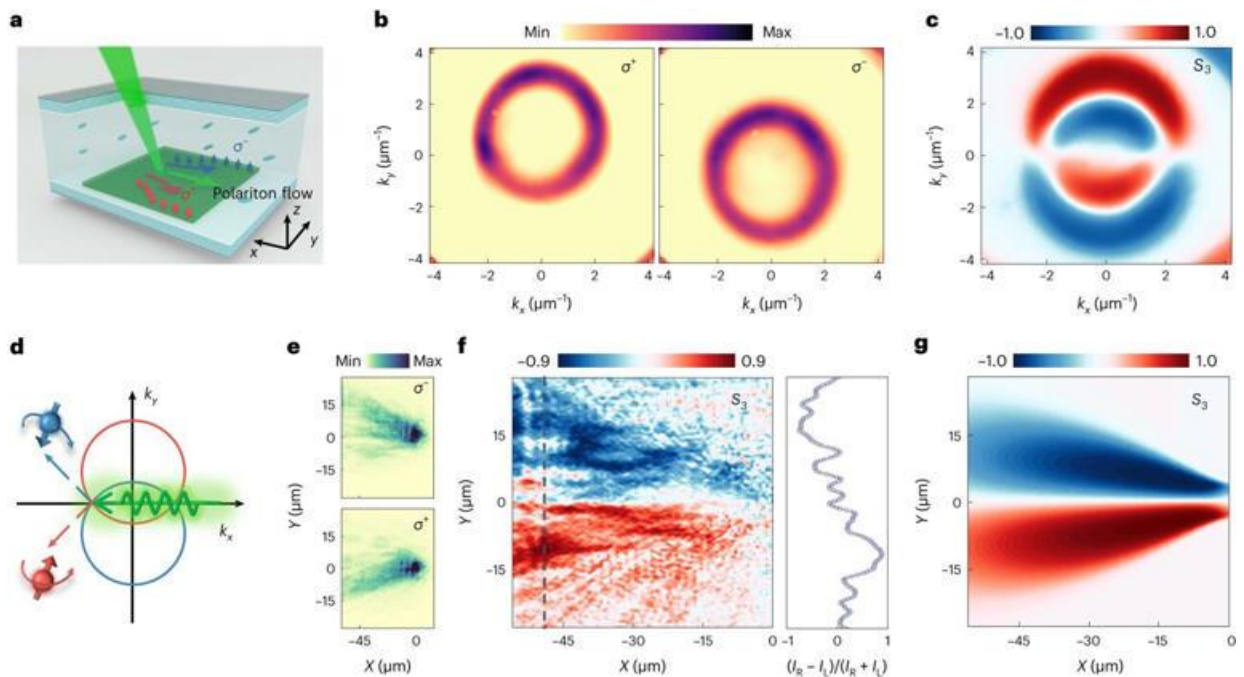
An electric field applied to a microcavity structure caused polaritons with different spins to move away from one another in opposite directions. This is visualized here by a spectrometer, with red polaritons spinning in one way separated from blue polaritons spinning the other way after they moved apart. Credit: Nanyang Technological University, Singapore

Researchers have found a way to manipulate special hybrid particles called polaritons—which behave like both light and matter—at room temperature. The breakthrough enables the use of polaritons in high-speed computing and data processing.

Polaritons have a property called "spin," which can move clockwise or anti-clockwise on an axis. How polaritons spin allows them to encode computer data. Changing how they spin and move thus modifies the data stored in polaritons.

But such changes to polaritons have only been possible at ultra-low temperatures close to the coldness of outer space, making them expensive and impractical to maintain.

Now, a study co-led by Nanyang Assistant Professor Su Rui from Nanyang Technological University, Singapore's School of Physical and Mathematical Sciences (SPMS) and School of Electrical and Electronic Engineering, along with Associate Professor Timothy Liew from SPMS, has shown that polaritons could be manipulated at room temperature when they are created.



Observation of the polariton spin Hall effect in the Rashba–Dresselhaus regime. Credit: Nature Photonics (2024). DOI: 10.1038/s41566-023-01375-x

The work is [published](#) in the journal *Nature Photonics*.

The particles are generated by shining a green laser on a material called cesium lead bromide with a layer of liquid crystal molecules in a microcavity structure.

The researchers controlled and changed the movements of the polaritons based on how they spin by applying an external voltage.

This method of manipulation allows the polaritons to store, transfer or process data at faster rates than current computing technologies because polaritons travel at the speed of light.

More information: Jie Liang et al, Polariton spin Hall effect in a Rashba–Dresselhaus regime at room temperature, *Nature Photonics* (2024). [DOI: 10.1038/s41566-023-01375-x](https://doi.org/10.1038/s41566-023-01375-x)

Provided by Nanyang Technological University

Breaking Physics: Inside the Strange World of Quantum Metals



New research reveals that quantum critical metals challenge traditional physics, offering insights that could enhance high-temperature superconductors. Credit: SciTechDaily.com

A new study examined how quantum critical metals, which behave unusually under low temperatures, challenge conventional physics theories.

The research reveals that these metals experience significant changes at quantum critical points, potentially informing the development of high-temperature superconductors.

Strange Metals and Quantum Fluctuations

A recent study led by Rice University physicist Qimiao Si sheds light on the mysterious behavior of quantum critical metals — materials that break the usual rules of physics at low temperatures. Published on December 9 in *Nature Physics*, the research explores quantum critical points (QCPs), where materials hover between two distinct states, such as being magnetic or nonmagnetic. These findings help explain the unique properties of these metals and offer new insights into high-temperature superconductors, which conduct electricity without resistance at relatively high temperatures.

At the heart of the study is quantum criticality, a state where materials become extremely sensitive to quantum fluctuations — tiny disruptions that change how electrons behave. While most metals follow well-established physical laws, quantum critical metals defy these expectations, displaying unusual and collective behaviors that have puzzled scientists for decades. Physicists refer to these systems as “strange metals.”

Role of Quasiparticles in Quantum Metals

“Our work dives into how quasiparticles lose their identity in strange metals at these quantum critical points, which leads to unique properties that defy traditional theories,” said Si, the Harry C. and Olga K. Wiess Professor of Physics and Astronomy and director of Rice’s Extreme Quantum Materials Alliance.

Quasiparticles, representing the collective behavior of electrons acting like individual particles, play a crucial role in energy and information transfer in materials. However, at QCPs, these quasiparticles vanish in a phenomenon known as Kondo destruction. Here magnetic moments in the material cease their usual interaction with electrons, dramatically transforming the metal’s electronic structure.

This change is evident in the Fermi surface, a map of possible electron states within the material. As the system crosses the QCP, the Fermi surface abruptly shifts, significantly altering the material’s properties.

Exploring Universal Behaviors

The study extends beyond heavy fermion metals — materials with unusually heavy electrons — to include copper oxides and certain organic compounds. All of these strange metals exhibit behaviors that defy traditional Fermi liquid theory, a framework used to describe electron motion in most metals. Instead, their properties align with fundamental constants such as Planck’s constant, governing the quantum relationship between energy and frequency.

Implications for Advanced Superconductors

The researchers identified a condition called dynamical Planckian scaling, where the temperature dependence of electronic properties mirrors universal phenomena like cosmic microwave background radiation and the radiation of the “black body” that approximates the behavior of stars. This discovery underscores a shared organizational pattern across various quantum critical materials, offering insights into creating advanced superconductors.

Quantum Transitions in New Materials

The research implications extend to other quantum materials, including iron-based superconductors and those with intricate lattice structures. One example is CePdAl, a compound where the interplay of two competing forces — the Kondo effect and RKKY interactions — determines its electronic behavior. By studying these transitions, scientists hope to decode similar phenomena in other correlated materials, where complex interelectronic relationships dominate.

Observing how these forces shape the material at QCPs could help scientists better understand transitions in other correlated materials or those with complex interelectronic relationships.

Reference: “Quantum critical metals and loss of quasiparticles” by Haoyu Hu, Lei Chen and Qimiao Si, 9 December 2024, *Nature Physics*.

[DOI: 10.1038/s41567-024-02679-7](https://doi.org/10.1038/s41567-024-02679-7)

This research, co-authored by Haoyu Hu and Lei Chen from Rice’s Department of Physics and Astronomy, Extreme Quantum Materials Alliance and Smalley-Curl Institute, was supported by the National Science Foundation, Air Force Office of Scientific Research, Robert A. Welch Foundation, Vannevar Bush Faculty Fellowship and European Research Council.



Will the world's fastest supercomputer please stand up?

- Oracle and xAI love to flex the size of their GPU clusters.
- It's getting hard to tell who has the most supercomputing power as more firms claim the top spot.
- The real numbers are competitive intel and cluster size isn't everything, experts told BI.

In high school, as in tech, superlatives are important. Or maybe they just feel important in the moment. With the breakneck pace of the [AI computing infrastructure](#) buildout, it's becoming increasingly difficult to keep track of who has the biggest, fastest, or most powerful supercomputer — especially when multiple companies claim the title at once.

"We delivered the world's largest and fastest AI supercomputer, scaling up to 65,000 Nvidia H200 GPUs," Oracle CEO Safra Catz and Chairman, CTO, echoed by Founder Larry Ellison on the company's Monday [earnings call](#).

In late October, Nvidia proclaimed [xAI's Colossus](#) as the "[World's Largest AI Supercomputer](#)," after Elon Musk's firm reportedly built a computing cluster with 100,000 Nvidia graphics processing units in a matter of weeks. The plan is to expand to [1 million GPUs](#) next, according to the Greater Memphis Chamber of Commerce (where the supercomputer is located.)

The good ole days of supercomputing are gone

It used to be simpler. "[Supercomputers](#)" were most commonly found in research settings. Naturally, there's an [official list ranking supercomputers](#). Until recently the world's most powerful supercomputer was named El Capitan. Housed at the Lawrence Livermore National Laboratory in California 11 million CPUs and GPUs from Nvidia-rival AMD add up to 1.742 Exaflops of computing capacity. (One exaflop is equal to one quintillion, or a billion billions, operations per second.)

"The biggest computers don't get put on the list," Dylan Patel, chief analyst at Semianalysis, told BI. "Your competitor shouldn't know exactly what you have," he continued. The 65,000-GPU supercluster Oracle executives were praising can reach up to 65 exaflops, according to the company.

It's safe to assume, Patel said, that Nvidia's largest customers, [Meta](#), [Microsoft](#), and [xAI](#) also have the largest, most powerful clusters. Nvidia CFO Colette Cress said 200 fresh exaflops of Nvidia computing would be online by the end of this year — across nine different supercomputers — on Nvidia's May earnings call.

Going forward, it's going to be harder to determine whose clusters are the biggest at any given moment — and even harder to tell whose are the most powerful — no matter how much CEOs may brag.

It's not the size of the cluster — it's how you use it

On Monday's call, Ellison was asked, if the size of these gigantic clusters is actually generating better model performance.

He said larger clusters and faster GPUs are elements that speed up model training. Another is networking it all together. "So the GPU clusters aren't sitting there waiting for the data," Ellison said Monday.

Thus, the number of GPUs in a cluster isn't the only factor in the computing power calculation. Networking and programming are important too. "Exaflops" are a result of the whole package so unless companies provide them, experts can only estimate.

What's certain is that [more advanced models](#) — the kind that consider their own thinking and check their work before answering queries — require more compute than their relatives of earlier generations. So training increasingly impressive models may indeed require an arms race of sorts.

But an enormous AI arsenal doesn't automatically lead to better or more useful tools.

Sri Ambati, CEO of open-source AI platform H2O.ai, said cloud providers may want to flex their cluster size for sales reasons, but given some (albeit slow) [diversification of AI hardware](#) and the rise of [smaller, more efficient models](#), cluster size isn't the end all be all.

Power efficiency too, is a hugely important indicator for AI computing since energy is an enormous operational expense in AI. But it gets lost in the measuring contest.

Nvidia declined to comment. Oracle did not respond to a request for comment in time for publication.

World's 1st mechanical qubit uses no light or electronics. It could lead to ultra-precise gravity-sensing tech.

World's 1st mechanical qubit uses no light or electronics. It could lead to ultra-precise gravity-sensing tech. © koto_feja/Getty Images

Scientists have created the world's first mechanical qubit: a tiny, moving system that stores quantum information using vibrations instead of electric currents or light.

[Qubits](#) are the fundamental units of [quantum information](#). Unlike the bits you'd find in a classical computer, qubits can exist as 0, 1, or a superposition of both, thanks to the weird inner workings of [quantum mechanics](#) and [entanglement](#).

Traditionally, these are made from [superconducting](#) circuits, charged [atoms](#) (ions), or light particles ([photons](#)). The new mechanical qubit, however, uses [phonons](#) — a type of "quasiparticle" — generated by vibrations within a precisely engineered sapphire crystal.

A quasiparticle is a concept used to describe the behavior and interactions of a group of particles as if they were acting as a single particle. In this case, phonons represent quasiparticles that essentially serve as carriers of vibrational energy.

The breakthrough could pave the way for ultra-sensitive sensor technologies capable of detecting forces like gravity, as well as new methods for maintaining stability in quantum computers for longer periods, the scientists said. They published their study Nov. 14 in the journal [Science](#).

Mechanical systems have historically been considered too challenging to be used as qubits because, thanks to the principles of quantum mechanics, they are never completely still. This means there is always residual motion that needs to be accounted for and controlled in order for them to work at the quantum level.

Likewise, mechanical oscillators — devices that store and transfer energy in the form of phonons — are typically subject to harmonic vibrations at evenly spaced energy levels. This is an issue, the scientists explained, because uniform spacing makes it difficult to isolate the two energy states needed to represent the 0 and 1 of a qubit.

"[The challenge] is whether you can make the energy levels unequally spaced enough that you can address two of them without touching the others," study co-author [Yiwen Chu](#), a physicist at ETH Zürich, told [Science](#).

The researchers tackled this problem by creating a "hybrid" system, coupling a sapphire crystal resonator measuring 400 micrometers (0.4 mm) with a superconducting qubit, and tuning the two to interact at slightly offset frequencies. When the resonator and qubit interacted, it blended their quantum states, resulting in unevenly spaced energy levels in the resonator — a phenomenon known as "anharmonicity."

This enabled the researchers to isolate two distinct energy states, effectively turning the resonator into a mechanical qubit.

While the mechanical qubit could hold and manipulate quantum information, the system's fidelity — a measure of how accurately it performs quantum operations — was recorded as just 60%. By comparison, state-of-the-art superconducting qubits often [achieve fidelities above 99%](#).

Even so, mechanical qubits may offer unique advantages, the scientists said. For instance, they can interact with forces like gravity in ways that other quantum systems cannot, making them promising candidates for the development of highly sensitive quantum sensors.

Mechanical qubits may also be able to store quantum information for longer periods of time, they said. This is critical for maintaining coherence — a measure of how long a system can stay stable and perform calculations using quantum data without interference.

The researchers are now working to link multiple mechanical qubits together to perform basic calculations, which they said would mark a key step toward practical applications for the technology.

Will we ever have quantum laptops?

Quantum computers are here. But could we ever build a quantum laptop?

Roughly 80 years ago, the world was at war. Under a shroud of secrecy, scientists in the U.K., Germany and the U.S. were creating the first electronic computers. These computers filled rooms, demanded vast quantities of electricity and enabled previously impossible calculations. Few of the people involved could have imagined that decades later, computers orders of magnitude more powerful would fit in a backpack — yet that's exactly what happened.

So, as we sit on the threshold of genuinely useful [quantum computing](#), could we ever see quantum laptops? "I think it's possible," [Mario Gely](#), a quantum computing researcher at the University of Oxford, told Live Science. "It's highly speculative, but I can't think of a fundamental reason why a quantum laptop would not be possible."

Here are some of the steps that will be needed to get there.

Scaling up qubit number

Before scientists can make a quantum laptop, they need to make a useful quantum computer, period. Questions remain over how many [qubits](#) — quantum equivalents to digital bits — are needed to create a genuinely useful quantum computer, or one that can solve a range of useful, real-world problems that elude [the best superclassical computers](#). But it's definitely higher than is currently possible.

[Stephen Bartlett](#), a theoretical quantum physicist and director of the University of Sydney's Nano Institute, thinks we could see genuinely useful quantum computers

by the end of this decade. "There's a bunch of open scientific challenges, which makes that pathway a bit murky, but we're getting close," Bartlett told Live Science.

For instance, newly developed quantum [charge-coupled device \(QCCD\) architecture](#) could be used to make two-dimensional arrays of qubits rather than one-dimensional ones — which would increase the density, and potentially the number, of qubits.

Reducing the errors in quantum computers

But scaling brings another challenge in building a miniature quantum computer: correcting errors, or "noise." "Our existing quantum components are noisy, so we need error correction, and that necessitates a large amount of redundancy," Bartlett said. Scientists need to either reduce errors or build error correction into quantum computers, and that requires even more qubits. Many scientists are trying to solve this problem.

For example, a [December 2023 study](#) tried to reduce errors by building a quantum computer with "logical qubits." In [another paper](#), published in April 2024, scientists designed a new type of qubit that behaved like an error-correcting logical qubit. Some scientists have even proposed using photons (light particles) as qubits, including [another study](#) that used a laser pulse. According to Peter van Loock, a professor of theoretical quantum optics at Johannes Gutenberg University of Mainz in Germany and co-author of the study, this approach has an "inherent capacity to correct errors".

So if, within a decade or two, powerful and useful quantum computers exist, the next step would be miniaturization.

Will quantum computers ever look like laptops? (Image credit: Aitor Diago via Getty Images)

Choosing different types of qubits

But to get really small, quantum computers may need to focus on a different type of qubit than is currently popular. Some of the most advanced quantum computers today — such as those made by IBM and Google — rely on [quantum processing units](#) filled with superconducting qubits. But the first quantum laptop probably won't use this technology.

That's because, by their nature, superconducting qubits must be cooled to a fraction above [absolute zero](#) — around 20 millikelvin — and that requires filling a room with dilution refrigerators. And companies like IBM aren't trying to get around this size constraint. For example, IBM's current [quantum computing roadmap](#) sets out

goals that include a 2,000-qubit quantum computer by 2033 — which would fill many rooms rather than one.

Quantum laptops may instead rely on trapped ion qubits, charged particles that exist in multiple states at once and that are suspended using electromagnetic fields, Bartlett and Gely explained. Although trapped ion systems work at room temperature and don't rely on room-sized refrigerators, the lasers they use are gigantic.

"At the moment, our laser system occupies approximately a cubic meter [35 cubic feet]," Gely said. "If we assume that ion traps are the future, then we need the lasers to become smaller."

And lasers must not only shrink but also become more advanced. Current systems are geared to constrain 100 ions. "How many qubits you can control with this volume of laser equipment is unclear," Gely said. "You can control more qubits than we have today, but certainly not the millions of qubits of a fully fledged quantum computer."

However, two recent advances could help with miniaturization. First, future QCCDs could aid miniaturization by increasing qubit density. Second, in July, Stanford researchers created [titanium-sapphire lasers that are 10,000 times smaller](#) than the ones they replace.

Related: [How does a secure phone line work?](#)

Miniaturization efforts will ramp up

Right now, scientists are focused on making quantum computers more powerful, not on shrinking them. "The drive for miniaturization is not as strong at the moment as the drive for performance, and that mimics the early days of conventional computers when we had mainframes," Bartlett said. "People thought of the most powerful computers as taking up a building. And you know, why would anyone seriously consider carrying one around in your backpack?"

The [history of computers](#) suggests quantum computers will roll out first for industrial, military and government applications before shifting to consumers. The apocryphal 1943 quote from [Thomas Watson Sr.](#) that there would be a "world market for maybe five computers" springs to mind.

Of course, the world market for PCs and laptops is immense, so could there ever be a similar explosion of demand for quantum PCs and laptops? "The question I always get in my quantum computing classes is, you know, 'When can I play Doom

on a quantum computer?" Bartlett said. "But why would you want to when you can play Doom perfectly well on your computer today?"

Instead, Bartlett suggested there might be "quantum personal apps like finance or something niche around information security" — but the truth is, nobody knows. Gely made the alternative suggestion of a quantum processor sitting alongside a classical processor. "It could be like you have a graphics card, but it would only be useful for certain tasks," Gely said.

It's not yet clear that quantum laptops would be useful for consumers. What experts can say with a high level of confidence is that all of the hardware obstacles — scaling the number of qubits, correcting errors and miniaturizing components — can be overcome. And yet, a future quantum laptop probably won't play Doom.

New quantum computer smashes 'quantum supremacy' record by a factor of 100 — and it consumes 30,000 times less power

published July 11, 2024

The 56-qubit H2-1 computer has broken the previous record in the 'quantum supremacy' benchmark first set by Google in 2019.



Scientists achieved an XMB score of 0.35, which means the H2 quantum computer can produce results without producing an error 35% of the time (Image credit: credit Quantinuum)

A new quantum computer has broken a world record in "quantum supremacy," topping the performance of benchmarking set by Google's Sycamore machine by 100-fold.

Using the new 56-qubit H2-1 computer, scientists at quantum computing company Quantinuum ran various experiments to benchmark the machine's performance levels and the quality of the qubits used. They published their results June 4 in a study uploaded to the preprint database [arXiv](#). The study has not been peer-reviewed yet.

To demonstrate the potential of the quantum computer, the scientists at Quantinuum used a well-known algorithm to measure how noisy, or error-prone, qubits were.

[Quantum computers](#) can perform calculations in parallel thanks to the laws of [quantum mechanics](#) and [entanglement](#) between qubits, meaning the fates of different qubits can instantly change each other. Classical computers, by contrast, can work only in sequence.

Adding more qubits to a system also scales up the power of a machine exponentially; scientists predict that quantum computers will one day perform complex calculations in seconds that a classical supercomputer would have taken thousands of years to solve.

The point where quantum computers overtake classical ones is known as "quantum supremacy," but achieving this milestone in a practical way would need a [quantum computer with millions of qubits](#). The largest machine today has only [about 1,000 qubits](#).

The reason we would need so many qubits for "quantum supremacy" is that they are inherently prone to error, so many would be needed to correct those errors. That's why many researchers are now focusing on building more reliable qubits, rather than simply adding more qubits to machines.

When quantum computers overtake classical ones is known as "quantum supremacy," but achieving this milestone would need a [quantum computer with millions of qubits](#). (Image credit: credit Quantinuum)

The team tested the fidelity of H2-1's output using what's known as the linear cross entropy benchmark (XEB). XEB spits out results between 0 (none of the output is error-free) and 1 (completely error-free), Quantinuum representatives said in a [statement](#). Scientists at Google [first tested the company's Sycamore quantum computer using XEB](#) in 2019, demonstrating that it could complete a calculation in 200 seconds that would have taken the most powerful supercomputer at the time 10,000 years to finish. They registered an XEB result of approximately 0.002 with the 53 superconducting qubits built into Sycamore.

But in the new study, Quantinuum scientists — in partnership with JPMorgan, Caltech and Argonne National Laboratory — achieved an XEB score of approximately 0.35. This means the H2 quantum computer can produce results without producing an error 35% of the time.

"We are entirely focused on the path to universal fault tolerant quantum computers," [Ilyas Khan](#), chief product officer at Quantinuum and founder of Cambridge Quantum Computing, said in the statement. "This objective has not changed, but what has changed in the past few months is clear evidence of the advances that have been made possible due to the work and the investment that has been made over many, many years."

Quantinuum previously collaborated with Microsoft to demonstrate "logical qubits" that had an [error rate 800 times lower than physical qubits](#). In the study, published in April, scientists demonstrated they could run experiments with the logical qubits with an error rate of just 1 in 100,000 — which is much stronger than the 1-in-100 error rate of physical qubits, [Microsoft representatives said](#). "These results show that whilst the full benefits of fault tolerant quantum computers have not changed in nature, they may be reachable earlier than was originally expected," added Khan.

World's 1st fault-tolerant quantum computer launching this year ahead of a 10,000-qubit machine in 2026

February 1, 2024

QuEra has dramatically reduced the error rate in qubits — with its first commercially available machine using this technology launching with 256 physical qubits and 10 logical qubits.



The new machine, which has 256 physical and 10 logical qubits, is expected to launch in late 2024. (Image credit: bpawesome/Getty Images)

The world's first commercial fault-tolerant quantum computer with "logical qubits" may be running before the year's end.

Logical qubits — physical quantum bits, or qubits, connected through [quantum entanglement](#) — reduce errors in quantum computers by storing the same data in different places. This diversifies the points of failure when running calculations. The new machine, which has 256 physical and 10 logical qubits, will launch in late 2024, representatives from QuEra, the startup that is building it, said in a [statement](#).

The announcement follows a new study, published Dec. 6, 2023 in the journal [Nature](#), in which researchers from Harvard, QuEra and several other institutions demonstrated a

functioning quantum computer that contained 48 logical qubits — the largest number of logical qubits tested to date.

"It is the first machine with quantum error correction," study co-author [Harry Zhou](#), a physicist at QuEra and Harvard University, told Live Science in an email. While this computer doesn't have enough power to be useful on its own, it provides a platform on which software programmers can start testing code for future quantum computers, Zhou said.

Why quantum computing needs error-correction

While conventional computers store information in bits with a value of either 0 or 1, quantum computers use qubits — which are a superposition between 0 and 1, thanks to the laws of [quantum mechanics](#).

Qubits can also be stitched together using quantum entanglement to exist in multiple states simultaneously. This enables them to perform many calculations much faster than classical computers — assuming you can build a quantum computer with enough of them. But qubits can easily be disturbed, making them notoriously error-prone. Roughly 1 in 1,000 fail, [versus 1 in 1 billion billion bits in conventional computers](#).

Quantum computers could outpace the best supercomputers if they incorporate millions of qubits, but the largest quantum computer built so far only has around 1,000 qubits, and qubits' high failure rate limits potential scale-up. Error correction could counteract qubits' tendency to fail, and building logical qubits is one way of doing it.

Logical qubits: turning down the quantum noise

The new error-correction system relies on data redundancy, where the same piece of data is stored in multiple places, Zhou said. Logical qubits perform the same calculations across several physical qubits — vastly reducing error rates if one or more physical qubits fail, because the data is available elsewhere so calculations can continue.

To make the logical qubit, researchers applied error-correcting computer code to regular qubits. They then set up logical gates, or circuits, between the qubits to entangle them. The quantum computer then calculates the 'syndrome' — a measure of whether it's likely an error has occurred or not. Using this information, the quantum computer corrects the errors and proceeds to the next step.

The new qubits represent a significant advance over past efforts. In 2023, the Google Quantum AI Lab [demonstrated a 2.9% error rate](#) using three logical qubits; QuEra's error rate is 0.5% with 48 logical qubits. The world leader is the University of Oxford, [which has achieved error rates of less than 0.01%](#) — but only between two-qubit gates.

Last year, IBM also demonstrated error-correction technology in its [127-qubit Heron chip](#) which reduced error rates fivefold compared with its other chips. But its first commercial fault-tolerant machine isn't expected until 2029.

QuEra plans to launch several quantum computers in the coming years, starting with a 30-logical-qubit, 3,000 physical qubit machine coming out in 2025. Its monster, a machine with more than 10,000 physical qubits and 100 logical qubits, is scheduled for 2026. "At 100 logical qubits, the [2026] machine can perform correct calculations that exceed the capability of today's supercomputers," Zhou said.

Future quantum computers will be no match for 'space encryption' that uses light to beam data around — with the 1st satellite launching in 2025

published March 27, 2024

Quantum computers will break encryption one day. But converting data into light particles and beaming them around using thousands of satellites might be one way around this problem.

Fearing that quantum computers will render encryption obsolete someday, scientists are proposing new technologies to protect sensitive communications. (Image credit: NanoStockk/Getty Images)

By converting data into light particles and beaming them around the world using satellites, we could prevent encrypted messages from being intercepted by a superpowerful quantum computer, scientists claim.

Currently, messaging technology relies on mathematical, or [cryptographic](#), methods of protection, including end-to-end encryption. This technology is used in WhatsApp — as well as by corporations, the government and the military — to protect sensitive data from being intercepted.

Encryption works by scrambling data or text into what appears to be nonsense, using an algorithm and a key that only the sender and recipient can use to unlock the data. These algorithms can, in theory, be cracked. But they are designed to be so complex that even the fastest supercomputers would take millions of years to translate the data into something readable.

"Security will be based on the information being encoded into individual light particles and then transmitted," [Tobias Vogl](#), professor of quantum communication systems engineering at TUM and co-author of the paper, said in a [statement](#). "The laws of physics do not permit this information to be extracted or copied."

That's because the very act of measuring a quantum system changes its state.

"When the information is intercepted, the light particles change their characteristics," he added. "Because we can measure these state changes, any attempt to intercept the

transmitted data will be recognized immediately, regardless of future advances in technology."

The challenge with traditional Earth-based quantum cryptography, however, lies in transmitting data over long distances, with a maximum range of just a few hundred miles, the TUM scientists said in the statement. This is because light tends to scatter as it travels, and there's no easy way to copy or amplify these light signals through fiber optic cables.

Scientists have also experimented with storing encryption keys in entangled particles — meaning the data is intrinsically shared between two particles over space and time no matter how far apart. A [project in 2020](#), for example, demonstrated "quantum key distribution" (QKD) between two ground stations 700 miles apart (1,120 km).

RELATED STORIES

When it comes to transmitting photons, however, at altitudes higher than 6 miles (10 kilometers), the atmosphere is so thin that light is not scattered or absorbed, so signals can be extended over longer distances.

The Quick3 system would involve the entire system for transmitting data in this way, including the components needed to build the satellites. The team has already tested each component on Earth. The next step will be to test the system in space, with a satellite launch scheduled for 2025.

They will probably need hundreds, or perhaps even thousands, of satellites for a fully working quantum communications system, the team said.

Quantum computers could overtake classical ones within 2 years, IBM 'benchmark' experiment shows

published June 15, 2023

A new experiment by IBM computers shows that quantum computers could soon outperform classical digital computers at practical tasks in the next two years.



A quantum computer (not the Eagle supercomputer used in the study). (Image credit: John D/Getty)

Quantum computers could beat classical ones at answering practical questions within two years, a new experiment from IBM computers shows. The demonstration hints that true quantum supremacy, in which quantum computers overtake classical digital ones, could be here surprisingly soon.

"These machines are coming," [Sabrina Maniscalco](#), CEO of Helsinki-based quantum-computing startup Algorithmiq, told [Nature News](#).

In the new study, described Wednesday (June 14) in the journal [Nature](#), scientists used IBM's [quantum computer](#), known as Eagle, to simulate the magnetic properties of a real material faster than a classical computer could. It achieved this feat because it used a special error-mitigating process that compensated for noise, a fundamental weakness of quantum computers.

Traditional silicon-chip-based computers rely on "bits" that can take just one of two values: 0 or 1.

By contrast, quantum computers employ quantum bits, or qubits, that can take on many states at once. Qubits rely on quantum phenomena such as superposition, in which a particle can exist in multiple states simultaneously, and on [quantum entanglement](#), in which the states of distant particles can be linked so that changing one instantaneously changes the other. In theory, this allows qubits to make calculations much faster, and in parallel, that digital bits would do slowly and in sequence.

But historically, quantum computers have had an Achilles' heel: The quantum states of qubits are incredibly delicate, and even the tiniest [disruption from the outside environment can mess with their states](#) — and thereby the information they carry — forever. That makes quantum computers very error-prone or "noisy."

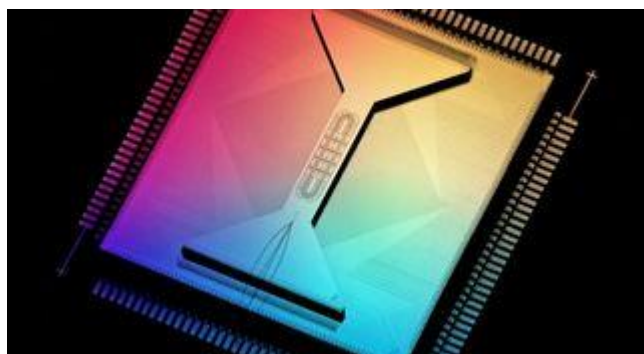
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In the new proof-of-principle experiment, the 127-qubit Eagle supercomputer, which uses qubits built on superconducting circuits, calculated the complete magnetic state of a two-dimensional solid. The researchers then carefully measured the noise produced by each of the qubits. It turned out that certain factors, such as defects in the supercomputing material, could reliably predict the noise generated in each qubit. The team then used these predictions to model what the results would have looked like without that noise, [Nature News](#) reported.

Bizarre particle that can remember its own past created inside quantum computer

published August 1, 2023

Non abelian-anyons' recollection of their past has enabled physicists to weave them into complex entangled designs with new behaviors.



Quantinuum's H2 quantum processor, on which the non-abelian anyons were created. (Image credit: Quantinuum)

A weirdo particle that can remember its own past has been created inside a [quantum computer](#), and scientists think it could be used to probe even deeper into quantum phenomena.

The quasiparticles, called non-abelian anyons, maintain records of their previous location when swapped with each other — enabling physicists to weave them together into complex entangled designs with new and weird behaviors.

To get a picture of how most subatomic particles behave, imagine the old street game where a ball is hidden under one of three identical cups, then shuffled around. Just like in this shell game, if you swap three perfectly identical particles around any number of times without tracking their movements, you'll have no way of guessing which is which by the time the cups have stopped moving. In quantum physics jargon, we say that particles are abelian: the order we observe them in doesn't matter because they are indistinguishable.

Yet for non-abelian anyons, the opposite is the case. First proposed by the theoretical physicist Frank Wilczek in 1982, each change to the positions of the bizarre particles causes them to become more entangled with each other, altering their quantum vibrations to form an ever-more-complex braid that remains visible even after they have been swapped.

For physicists designing quantum computers, this gives non-abelian anyons some very alluring properties. Quantum bits, or qubits, can easily be exposed to noise

and scrambled, meaning that scientists often try to encode information in quantum systems not in the bits themselves, but in how the bits are arranged relative to each other.

For an analogy, imagine a book “where every page is empty, but if you look at all the pages at once, the information slowly adds up,” [Henrik Dryer](#), a theoretical physicist at the quantum computing firm Quantinuum, which created the particle, told Live Science. “Even if you scratch out one page, it doesn't matter, because the information is in the correlation between the pages.”

Dryer explained that until now, physicists working on quantum computers have connected the pages using abelian particles, or ones that are completely interchangeable. This is an effective method to account for noise, but because abelian particles are indistinguishable from each other, it requires computationally intense workarounds to prevent the qubits from getting mixed up.

To find a way around this, Dryer and his colleagues developed a new quantum computer, named H2, that trapped ions of barium and ytterbium inside powerful magnetic fields, before tuning the ions with lasers to transform them into qubits.

By entangling these qubits with each other into a complex braid-like arrangement, the researchers found they had given the qubits properties exactly like those predicted for non-abelian anyons — a result which they say is equivalent to having created the elusive particles.

“It's not simulated, it's the real thing. And that is just the mathematical definition,” Dryer said. “Let's take water ice: if you make a crystal that has the same properties as ice, but without H₂O, then you could say it was a simulation, right?” But in this case, the definition of a non-abelian anyon is only about entanglement.

Besides helping build more robust quantum systems, the scientists say that non-abelian anyons will help them to design more advanced experiments to probe even deeper into weird quantum effects that emerge from large-scale entanglement.

“I think the most exciting thing that comes out of this is using these kinds of states, not for computational purposes, but just for asking research questions,” Dryer said. “This could provide some value to people as a science tool by performing new experiments that you couldn't with a classical computer.”

World's 1st graphene semiconductor could power future quantum computers

published January 8, 2024

Scientists overcame a limitation in graphene to harness the material as a working semiconductor at terahertz frequencies with 10 times the mobility of silicon.

Like light, electrons in graphene have quantum mechanical wave-like properties that can be accessed in devices, making such a semiconductor a good choice for use in future quantum computers. (Image credit: Christopher McKenney/Georgia Tech)

Scientists have created the world's first working graphene-based semiconductor, which could pave the way for chips that power much faster PCs and quantum computers in the future.

The new semiconducting material, made from epitaxial graphene (a particular crystal structure of carbon chemically bonded to silicon carbide), allows for more mobility than [silicon](#), meaning electrons move with less resistance. Transistors made in this way can operate at terahertz frequencies — 10 times faster than the silicon-based transistors used in chips used today — the researchers wrote in a study published Jan. 3 in the journal [Nature](#).

Semiconductors have properties of both conductors and insulators. At the right temperature range, electrons move through the semiconductor material — but only if a certain amount of energy is applied.

Almost every chip uses a semiconductor made from silicon, but the material is reaching its limits, lead researcher [Walt de Heer](#), a professor at the Georgia Institute of Technology, told Live Science in an email. These limits include the maximum speed at which transistors can "switch" between their on-off positions, the heat they generate through resistance and the smallest size people can make them. This means the rapid advancements we've seen throughout the [history of computing](#) are beginning to slow.

[Graphene](#), meanwhile, is made from a single layer of carbon atoms tightly bound in a hexagonal lattice, and is a better conductor than silicon, meaning electrons move with less resistance through the material.

Despite its favorable properties, graphene has never been harnessed in electronics because of the lack of a "band gap" — a minimum amount of energy needed to move electrons when an electric field is applied to it. Band gaps are what enable transistors to switch on and off.

To function as a working transistor, the graphene must be treated in some way, but in the past, this has damaged its properties, de Heer said.

But the researchers worked around this challenge by fusing graphene onto silicon carbide using special furnaces and a special heating and cooling process. By putting atoms on the graphene that "donate" electrons to the system, which is known as "doping", they created a functional graphene semiconductor with a band gap.

Not only is this the first graphene-based semiconductor to work, but it can also be integrated into existing manufacturing processes. The transition from making silicon wafers to the silicon carbide wafers used in epitaxial graphene is "quite feasible," de Heer said.

Graphene-based semiconductors also have a potential future use in quantum computing, the researchers wrote in the study.

"Like light, electrons in graphene have quantum mechanical wave-like properties that can be accessed in devices, particularly at very low temperatures," de Heer said.

This is an area the scientists hope to explore in subsequent research, but de Heer said it remains to be seen whether graphene-based semiconductors can work better than the current [superconducting](#) technology, which is used in the most advanced quantum computers.

Scientists create light-based semiconductor chip that will pave the way for 6G

published December 17, 2023

By combining photonic and electronic components, scientists have built a prototype communications chip that can effectively access high enough radio frequency bandwidths for uses including advanced radar as well as 6G and 7G.

6G support microchip on smartphone circuit board, next generation smart iot communication microprocessor, 3d rendering futuristic fast real time mobile network internet technology concept. (Image credit: Black_Kira via Getty Images)

A first-of-its-kind chip architecture that uses both electronic- and light-based components could pave the way for 6G technology.

The research, published Nov. 20 in [Nature Communications](#), offers a blueprint for communications chips needed for advanced radar, satellite systems, advanced wireless networks (Wi-Fi), and even future generations of 6G and 7G mobile technology. By integrating light-based, or photonic components, into a conventional electronic-based circuit board, researchers dramatically increased [radio frequency \(RF\) bandwidth](#), while demonstrating improved signal accuracy at high frequencies.

They built a working prototype of the networking semiconductor chip, measuring 0.2 by 0.2 inches (5 by 5 millimeters), by sourcing a silicon wafer and attaching the electronic and photonics components — in the form of "chiplets" — like Lego bricks.

Related: [How radar works: The technology made famous by war](#)
Crucially, they also improved how the chips filtered information.

Wireless transceivers send out data, and microwave filters built into conventional chips block out signals in the wrong frequency range. Microwave photonic filters perform the same function for light-based signals. But it's been extremely challenging to combine photonic and electronic components, and effective microwave photonic filters, on one chip.

But by fine-tuning precisely into specific frequencies at higher bands, which tend to be crowded, more information can flow through the chip more accurately, according to the study. This is important for future wireless technologies which will come to rely on higher frequencies. These have shorter wavelengths, and can therefore carry more energy, which equates with a higher bandwidth for data.

"Microwave photonic filters play a crucial role in modern communication and radar applications, offering the flexibility to precisely filter different frequencies, reducing electromagnetic interference and enhancing signal quality," said research team leader [Ben Eggleton](#), pro-vice-chancellor (research) at the University of Sydney.

Devices that tap into 5G networks, like smartphones, transmit and receive data at varying radiofrequency ranges — ranging from low band (under one gigahertz) to high band (24 to 53 GHz) in the U.S., [Verizon](#) said.

Higher frequencies allow for faster speeds due to the greater energy capacity of the shorter wavelengths, but there's a higher chance of interference and obstruction. This is because shorter wavelengths struggle to pierce through larger surfaces and objects, also reducing signal range.

Meanwhile, 5G data speeds average 138 megabits per second in the U.S., according to [OpenSignal](#), and carriers run the networks on bands ranging from 2 to 4 GHz. 6G, which is expected to become mainstream by the 2030s will operate on a higher frequency — starting from 7 to 15 GHz, according to the [Global Systems for Mobile Communications Association \(GSMA\)](#).

The highest 6G bands, for industrial applications, however, will need to be above 100 GHz and possibly even reach 1,000 GHz, according to the [University of Liverpool](#), and speeds could reach a theoretical maximum of 1,000 gigabits per second. This means there's a need to build communications chips with a significantly higher RF bandwidth, and the advanced filtering to eliminate the interference at these higher frequencies. This is where advancements in chip architecture come in — with photonics playing a key role in the networking semiconductor chips that will be used to power 6G devices.

New brain-like transistor goes 'beyond machine learning'

published December 20, 2023

Scientists have previously only gotten 'synaptic transistors' to work under cryogenic conditions, but this is the first that can operate at room temperature — while outperforming today's best-in-class machine learning systems.

Scientists have designed a transistor that stores and processes information like the human brain and can perform cognitive tasks that most artificial intelligence (AI) systems today struggle with.

This technology, known as a "synaptic transistor," mimics the architecture of the human brain — in which the processing power and memory are fully integrated and found in the same place. This differs from conventional computing architecture, in which the processor and memory are physically separate components.

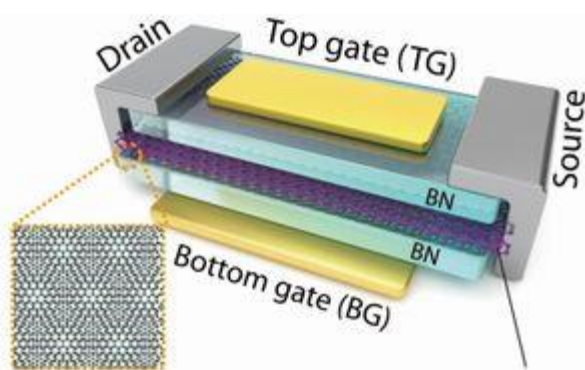
"The brain has a fundamentally different architecture than a digital computer," [Mark Hersam](#), research co-leader and professor of material science, engineering and computing at Northwestern University, [said in a statement](#). "In a digital computer, data move back and forth between a microprocessor and memory, which consumes a lot of energy and creates a bottleneck when attempting to perform multiple tasks at the same time."

Because of its full integration between computing power and memory, the synaptic transistor can achieve significantly higher energy efficiency and move data extremely fast, researchers wrote in the study, published Dec. 20 in the journal [Nature](#). This new form of computing architecture is needed, the scientists said, because relying on conventional

electronics in the age of big data and the growing demand for AI computing workloads will lead to unprecedented energy consumption.

Scientists have built synaptic transistors before, the researchers said, but they only operated at extremely cold temperatures. But the new transistor uses materials that work at room temperature.

Conventional electronics pack transistors onto a silicon wafer, but in the new synaptic transistor, the researchers stacked bilayer graphene (BLG) and hexagonal boron nitride (hBN) and purposefully twisted them to form what's known as a moiré pattern.



A schematic showing the different layers within the new technology. (Image credit: Mark C. Hersam/Northwestern University)

When they rotated one layer relative to the other, new electronic properties emerged that didn't exist in either layer separately. Getting the transistor to work at room temperature required using a specific degree of twist and adopting a near-perfect alignment between hBN and BLG.

The researchers tested the chip by first training it on data so it could learn to recognize patterns. Then they showed the chip new sequences that were similar to the training data but not the same. This process, known as associative learning, is one that most machine learning systems can't perform well.

"If AI is meant to mimic human thought, one of the lowest-level tasks would be to classify data, which is simply sorting into bins," Hersam said. "Our goal is to advance AI technology in the direction of higher-level thinking. Real-world conditions are often more complicated than current AI algorithms can handle, so we tested our new devices under more complicated conditions to verify their advanced capabilities."

In one exercise, the researchers trained the AI to detect the sequence 000. The researchers then asked the AI to identify similar patterns — for example, by presenting it with 111 and 101. The sequences 000 and 111 aren't the same, but the AI figured out they were both three digits in a row.

This seems simple enough, but today's AI tools struggle with this type of cognitive reasoning. In further experiments, the researchers also threw "curveballs" at the AI by giving it incomplete patterns. But the AI using the chip still demonstrated associative learning, the researchers said.

"Thus far, we have only implemented the moiré synaptic transistor with hBN and BLG," Hersam told Live Science in an email. "However, there are many other two-dimensional materials that can be stacked into other moiré heterostructures. Therefore, we believe that we have only just begun to scratch the surface of what is possible in the emerging field of moiré neuromorphic computing."

The features the scientists observed in this experimental transistor could prime future generations of the technology to be used in highly energy-efficient chips that power advanced AI and machine learning systems, Hersam added.

Wireless tech could replace Bluetooth at short distances and boost battery life 5-fold

published December 11, 2023

This groundbreaking wireless technology can make your smartphone or wearable devices last up to five times longer on a single charge.

Scientists have created a new wireless technology that could one day rival the reigning wireless communication technology, Bluetooth. The new technology requires so little power it could make devices last five times longer on a single charge.

Currently, the main wireless technologies — including Wi-Fi, [5G](#) and [Bluetooth](#) — embedded in devices such as smartphones and wearables, as well as smart home devices, rely on classical radio configurations. These transmit data through electromagnetic waves generated by electromagnetic field modulation. But the alternative technology instead relies on electric field modulation. Signal-transmitting devices swap out power amplifiers used in conventional wireless technologies for voltage amplifiers which generate a short-range electric field.

These voltage amplifiers also generate a weak electromagnetic field, but the receivers — untuned electrodes rather than tuned antennae — are configured to only pick up on data that travels via the electric field. (Conventional radio systems create electric fields alongside electromagnetic fields, but they decay very quickly and aren't used to transmit information.)

Power is consumed on the receiving device only when there's a charge or discharge on the receiving electrode — a process known as capacitive coupling — and not by the continuous transfer of energy through air as in classical radio configurations. As a result, the new tech, dubbed "Electric Potential Sensing Communication" (EPSComm), consumes a fraction of the power that Bluetooth uses.

"This new technology means that wearable and mobile devices will be able to operate longer on a battery charge. More fundamentally it will be possible to use smaller batteries and miniaturize devices even further, thanks to the energy savings brought about by this new communication technology. This opens up new possibilities for tiny wearable devices, such as earables (smart earbuds), smart rings, or even electronics integrated into garments," [Daniel Roggen](#), a professor of wearable technologies at the University of Sussex, told Live Science in an email. In experiments, Roggen's team found that optimized EPSComm consumed 10 times less power than Bluetooth, he said, which likely translates to device batteries lasting between four and five times longer between charges.

EPSComm achieved a data throughput of up to 600 kilobits per second, which Roggen said is fast enough for audio, video and virtual reality (VR) applications. While Bluetooth often has higher data transmission rates now, the first generation of Bluetooth transmitted at only 125 kbps.

The electrical signals from EPSComm travel much shorter distances than Bluetooth, which is the trade-off, but that also means a reduced chance of eavesdropping or signal interference.

Rather than completely replacing Bluetooth, however, the new tech may complement the wireless standard in future devices, Roggen said.

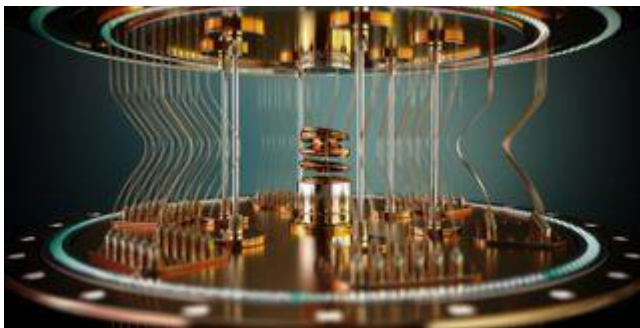
Somebody, for example, could connect their headphones to their smartphone using EPSComm, but if they walk away, the system would dynamically switch to a Bluetooth connection, which has a much longer range.

The team built several prototype EPSComm devices, but the transmitters and receivers were approximately 1.2 by 1.2 inches (3 by 3 centimeters). That's too large to fit into today's smartphones or wearable devices, such as [running headphones](#). Having established a working prototype, the researchers are looking for industrial partnerships to reduce the size of the components so they will fit into small personal devices.

How could this new type of room-temperature qubit usher in the next phase of quantum computing?

published January 29, 2024

The qubit attained quantum coherence for 100 nanoseconds, which an expert described as an "important milestone" in quantum computing research.



The new qubit used a pentacene-based chromophore — a dye molecule that absorbs light and emits color — embedded into a new metal-organic framework (MOF). (Image credit: adventtr/Getty Images)

Scientists have built a qubit, or quantum bit, that can achieve "quantum coherence" at room temperature — something normally only possible at temperatures close to [absolute zero](#).

To achieve quantum coherence — a stable state in which the weird laws of [quantum mechanics](#) can be observed — qubits must normally be cooled down to minus 459 degrees Fahrenheit (minus 273 degrees Celsius) or they succumb to disturbances and fail, which is known as decoherence.

To get around this, the new qubit used a pentacene-based chromophore — a dye molecule that absorbs light and emits color — embedded into a new metal-organic framework (MOF). Its properties meant scientists could observe quantum coherence briefly at room temperature, the scientists said in a new paper published Jan. 3 in the journal [Science Advances](#).

While classical computers encode data in bits — expressed as either 1 or 0 — quantum computers use qubits, which can be expressed as a superposition of 1 and 0, meaning it can be both states at the same time until physically observed.

Most physical qubits create a superposition between an electron's spin-up and spin-down positions — two binary states that behave as 1 and 0. They are normally

a line of metal, or a tiny loop, that behaves as an atom. Google uses aluminum in its qubits, while IBM uses a mix of aluminum and niobium, according to [Scientific American](#).

Multiple qubits that encode information via electron spin can also be joined by [quantum entanglement](#) — when the states of two or more particles are linked — meaning the entangled qubits can exist in many states simultaneously. This is what makes quantum computers potentially so much more powerful than classical computers if built with enough qubits.

How the new type of qubit works

Electrons in chromophores can be excited via a process called singlet fission, in which they absorb light and change their spin states. In the past, researchers used singlet fission to create superposition in qubits, but they only achieved this below minus 324 F (minus 198 C), the scientists wrote in the paper.

For the new study, the scientists used a chromophore based on pentacene hydrocarbon, in which pentagonal rings of carbon and hydrogen are linked together. To achieve this same quantum state at higher temperatures, the researchers trapped the chromophore molecules in the MOF — a unique crystalline material composed of metal ions and bound by organic molecules.

The MOF almost completely restricted the dye molecule's movement, helping keep any excited electrons in an entangled state. The scientists then excited the electrons in the chromophore via singlet fission by exposing them to microwave pulses. Tiny holes in the crystalline structure, known as nanopores, enabled the electrons to rotate at a tiny and specific angle, the study's lead author [Nobuhiro Yanai](#), an associate professor of chemistry at Kyushu University, said in a [statement](#).

This slight rotation enabled excited electrons to transition from two pairs of electrons in excited "triplet states" — in which electrons from different molecular orbits have parallel spins — into one set of four electrons in the less stable "quintet state," in which the electron spins are antiparallel — meaning they are parallel but are moving in opposite directions. In this quintet state, the laws of quantum mechanics dominate.

Following this process, the researchers observed quantum coherence in these four electrons in a quintet state for over 100 nanoseconds at room temperature (one nanosecond is a billionth of a second).

Pursuing room-temperature quantum computers

It's the first room-temperature quantum coherence of entangled quintet-state electrons, said study co-author [Yasuhiro Kobori](#), a professor of chemistry at Kobe University, in the statement.

In follow-up work, the team hopes to create more stable qubits by adding other "guest" molecules that further restrict the electron motion, or by playing around with the underlying structure of the MOF, Yanai said in the statement.

While the new research is unlikely to lead to room-temperature quantum computing in the foreseeable future, the breakthrough adds to the body of work that's gone into building qubits that can achieve quantum coherence at room temperature. Indeed, producing stable qubits at room temperature has been a hope for a long time, [Vlatko Vedral](#), a professor of quantum information science at the University of Oxford, told Live Science.

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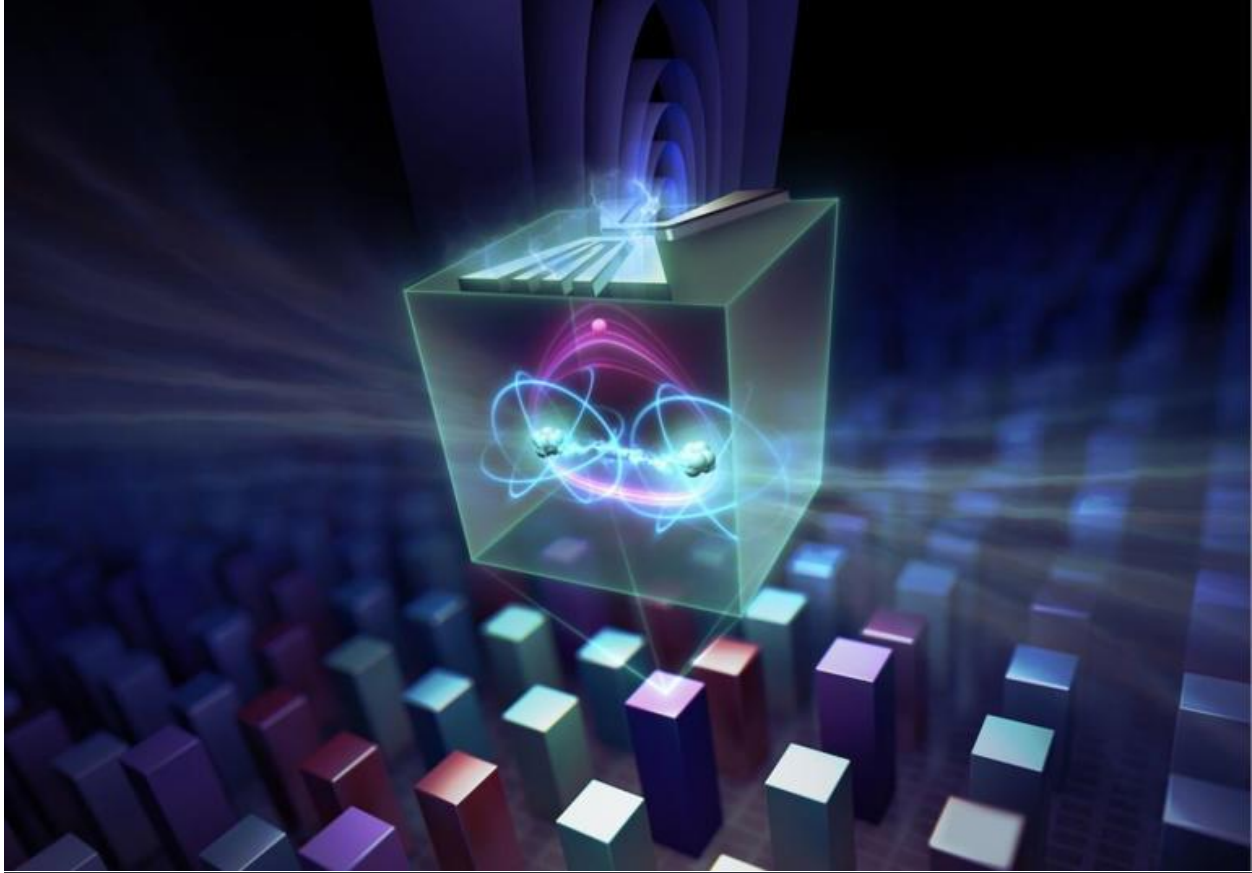
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Such room-temperature computing would avoid the need for error correction, he said. This is because to work at room temperature, the qubits would by design need to withstand the disruptive forces that render them unstable and prone to decoherence.

"In this paper, long spin coherence times are indeed reported which is a significant advancement," he said. "However, I am not sure how easy it is to scale this up, and — in particular — how easy it is to control the interactions between qubits. It seems to me this will be the bottleneck since isolated qubits with long coherence times are not of much use for quantum computation." In other words, to make a powerful computer, you need many qubits to perform calculations.

Despite casting doubt on the utility of this specific discovery, Vedral hailed it as "an important milestone," adding this body of research is more promising in the long run than developing ways to perform quantum error correction.

From sand to superposition: A key step toward a powerful silicon quantum computer



Artistic representation of an engineered atomic array in silicon. In this example, each site of the array hosts two closely spaced antimony atoms. This atomic pair could serve as a building block to realise and control up to six nuclear spin qubits with a single electronic gate. Credit: Tony Melov

Whether it's our phones, cars, televisions, medical devices or even washing machines, we now have computers everywhere.

Using bigger computers, we solve bigger problems like managing the operation of a power grid, designing an aircraft, predicting the weather or providing different types of artificial intelligence (AI).

But all these machines work by manipulating data in the form of ones and zeros (bits) using classical techniques that have not changed since the abacus was invented in antiquity.

Realizing the benefits of quantum computing

Humankind's tireless technological advance now faces us with problems that cannot be solved even with the most powerful classical supercomputers.

For those challenges, we need a quantum computer. By employing the strange rules of quantum mechanics, we may be able to benefit many sectors, including vaccine and drug design, financial risk management, industrial data processing, secure data and communications systems as well as machine learning and AI.

Quantum computers store information in quantum bits or "qubits." A qubit can be any quantum object with two or more states—for example, a single electron that can be in a spin-up or spin-down state.

Using microwaves or laser beams, these qubits can be manipulated and even put into states that are a quantum mechanical mixture of one and zero—a condition known as "superposition." This versatility builds the framework for the awesome potential of a quantum computer.

Quantum computers can deal with computational tasks so that otherwise impossible calculations—processes that would take centuries on classical supercomputers—can be performed within hours.

But tackling complex computational problems relevant to society will need a powerful quantum computer—with a chip architecture, size and complexity comparable to those of state-of-the-art classical processors.

In other words, a quantum processor with an immense number of physical qubits, arranged in ordered arrays, or "scalable arrays."

Building quantum devices

Silicon—made from beach sand—is the key material for today's information technology industry because it is an abundant and versatile semiconductor.

We are already building quantum devices made from silicon engineered with dopant atoms—impurities intentionally added from other elements to change the properties of silicon.

We have shown how these devices can be programmed with quantum states to form the qubits for a quantum computer.

However, the roadblock so far is that qubits are very susceptible even to tiny imperfections in their environment causing the qubit to lose its information (known as decoherence) requiring a reset of the computation.

Our previous work showed that qubits made from dopant atoms in silicon are very durable when exposed to changes in the environment.

Now, our latest study, published in *Advanced Materials*, demonstrates how to construct large arrays of single dopant atoms in a silicon chip, that could form the basis of a robust quantum computer.

The desirable attributes of silicon and its dopant atoms for making durable qubits allow the adaption of standard silicon fabrication processes for new purposes in the dawning quantum era.

Our discovery is a way of building large-scale ordered arrays of atoms implanted into a silicon device. But not just any atoms. Our breakthrough is how to make these arrays out of elements that are promising new qubit candidates.

Implanting dopant atoms into silicon is a standard technique for making silicon chips.

We discovered that if we equip our silicon chips with tiny surface electrodes, we can reliably register the implantation of a single atom from the electric signal it creates when stopping in the chip.

These signals were found to be surprisingly strong, allowing us to construct atomic arrays in silicon devices with very high fidelity.

Now, new physical qubits, including antimony, bismuth and germanium offer powerful features that provide new options for silicon quantum computers.

Making scalable donor arrays in silicon

As our new paper shows, the technique even works for diatomic antimony molecules so that each implantation event results in closely spaced pairs of antimony atoms.

These pairs are able to host many high-quality physical qubits that can be controlled with a single electronic gate, known as "multi-qubit-gate-operation."

Now that we have shown that our novel technique works, the most important next step is to build a quantum processor from atomic arrays that are configured with the necessary circuitry to program and control the qubit interactions.

The ability to create scalable atomic arrays developed from well-established industry-manufacturing tools adapts silicon, the most important element for classical computing, to build reliable quantum computers.

More information: Alexander M. Jakob et al, Scalable Atomic Arrays for Spin-Based Quantum Computers in Silicon, *Advanced Materials* (2024). DOI: [10.1002/adma.202405006](https://doi.org/10.1002/adma.202405006)

Provided by University of Melbourne

A physical qubit with built-in error correction

There has been significant progress in the field of quantum computing. Big global players, such as Google and IBM, are already offering cloud-based quantum computing services. However, quantum computers cannot yet help with problems that occur when standard computers reach the limits of their capacities because the availability of qubits or quantum bits, i.e., the basic units of quantum information, is still insufficient.

One of the reasons for this is that bare qubits are not of immediate use for running a quantum algorithm. While the binary bits of customary computers

store information in the form of fixed values of either 0 or 1, qubits can represent 0 and 1 at one and the same time, bringing probability as to their value into play. This is known as quantum superposition.

This makes them very susceptible to external influences, which means that the information they store can readily be lost. In order to ensure that quantum computers supply reliable results, it is necessary to generate a genuine entanglement to join together several physical qubits to form a logical qubit. Should one of these physical qubits fail, the other qubits will retain the information. However, one of the main difficulties preventing the development of functional quantum computers is the large number of physical qubits required.

"Our laser pulse was converted to a quantum optical state that gives us an inherent capacity to correct errors," stated Professor Peter van Loock of Mainz University. "Although the system consists only of a laser pulse and is thus very small, it can—in principle—eradicate errors immediately." Thus, there is no need to generate individual photons as qubits via numerous light pulses and then have them interact as logical qubits.

"We need just a single light pulse to obtain a robust logical qubit," added van Loock. To put it in other words, a physical qubit is already equivalent to a logical qubit in this system—a remarkable and unique concept. However, the logical qubit experimentally produced at the University of Tokyo was not yet of a sufficient quality to provide the necessary level of error tolerance. Nonetheless, the researchers have clearly demonstrated that it is possible to transform non-universally correctable qubits into correctable qubits using the most innovative quantum optical methods.

More information: Shunya Konno et al, Logical states for fault-tolerant quantum computation with propagating light, *Science* (2024). [DOI: 10.1126/science.adk7560](https://doi.org/10.1126/science.adk7560)

Olivier Pfister, Qubits without qubits, *Science* (2024). [DOI: 10.1126/science.adm9946](https://doi.org/10.1126/science.adm9946)

Provided by Johannes Gutenberg University Mainz

History Shows How to Win the Quantum Computing Race

In 1981, physicist Richard Feynman first theorized the creation of [quantum computers](#) that harnessed the principles of quantum physics to process calculations that would take standard computers millennia or longer to compute. Over the next four decades, however, research failed to advance significantly enough for the machines to have much impact on society.

But breakthroughs in 2023 signaled that quantum computers have embarked on a new era, one that may unleash a technological revolution full of possibilities—some good and some bad. On the positive side, quantum computers could lead to the development of new drugs to combat cancer. On the negative side, however, they can break the encryption we use multiple times per day for everything from sending texts to financial transactions.

But this isn't the first quantum race in history that pitted the U.S. against its adversaries—and the past provides a guide for how the U.S. can win the coming computing revolution. In the 1940s, a quantum race produced the creation of nuclear weapons and unleashed a technology explosion. Crucially, the U.S. won the competition to harness the new technology. Not only did American scientists create the first nuclear weapons, but advancements in lasers and in chips for computers made the U.S. the home for global innovation.

That only happened, however, because policymakers supplied the funding and support necessary to ensure superiority. In 2024, by contrast, a key quantum funding bill has stalled while allies and adversaries are sinking billions into quantum research and development. Without action, history shows that the U.S. risks falling behind especially in leadership for the revolutionary power of quantum technologies.

Quantum physics developed in Europe in the 1920s and 1930s. As World War II erupted in the 1930s and 1940s, German, Hungarian, and Italian physicists escaped to the U.S. Many of them joined [J. Robert Oppenheimer](#) and his American colleagues in the Manhattan Project—which birthed the atomic bomb and simultaneously elevated the U.S. as the home for quantum science.

In the ensuing decades, Feynman and other scientists who cut their teeth on the Manhattan Project inspired profound innovation from quantum physics that became woven into the fabric of American life. The first quantum revolution created nuclear weapons and energy, global positioning systems, lasers, magnetic resonance imaging, and the chips that would power the rise of the personal computer.

Although many countries like the Soviet Union built nuclear weapons, none rivaled the U.S. in pioneering innovation. The Soviet launch of [Sputnik](#) in 1957 and the space race produced an explosion of federal funding for science and education that was at the root of American success. Further, the Department of Defense provided crucial sponsorship for visionary, but risky, research that developed the internet, stealth capabilities, and voice assistants like Siri. This combination propelled the U.S. to unparalleled innovation heights in the decades after World War II.

The technologies born from the first quantum revolution were at the core of American national defense, and also reshaped civilian life in the U.S., most especially through the development of personal computers and the Information Revolution.

But even as personal computers were [beginning to revolutionize American life](#) in 1981, Feynman insisted in a pivotal lecture that something more was possible. He argued that a quantum computer — with processing power magnitudes greater than even the highest performing computer then in existence — offered the only way to unlock the true knowledge of the world. Feynman admitted, however, that building such a machine required staggering complexity.

The ensuing four decades have proved him correct on the obstacles involved. Designing a quantum computer required tremendous advances in theory as well as materials and components. Since the 1980s, progress has crept along, and many joked that quantum computers would always be 10 to 20 years away.

In 1994, mathematician Peter Shor discovered an algorithm that created a method for a quantum computer to calculate the large prime numbers used in encryption. Despite this breakthrough, the pace of developments since Shor's discovery has remained glacial. Persistent funding from the National Security Agency and the Department of Defense — especially the former — has sustained

innovation, but the results have been uneven, because scientists have been unable to build a quantum computer that wasn't plagued by errors.

In the past 10 years, private technology companies such as IBM, Google, and Microsoft have made significant investments in quantum computing, which have pushed the field to new heights of maturity and accelerated a global race for quantum dominance — one with major national security and cybersecurity implications.

Even so, today's quantum computers still have yet to outperform standard computers due to regular errors caused by radiation, heat, or improper materials. These errors make quantum computers useless for things like, for example, designing new drugs, because scientists can't replicate an experiment accurately. But all of that is changing quickly.

Advances by IBM and a Harvard team in 2023 demonstrated that error correction is on the horizon and the era of quantum utility has arrived. In July 2023, [IBM announced](#) peer reviewed evidence from experiments that indicated the company had made strides in mitigating the errors that have long plagued quantum computing. A few months later in December, a Harvard team and the company QuEra [published](#) encouraging results from experiments that showed they too had developed a quantum process with enhanced error-correction.

Read More: [How the AI Revolution Will Reshape the World](#)

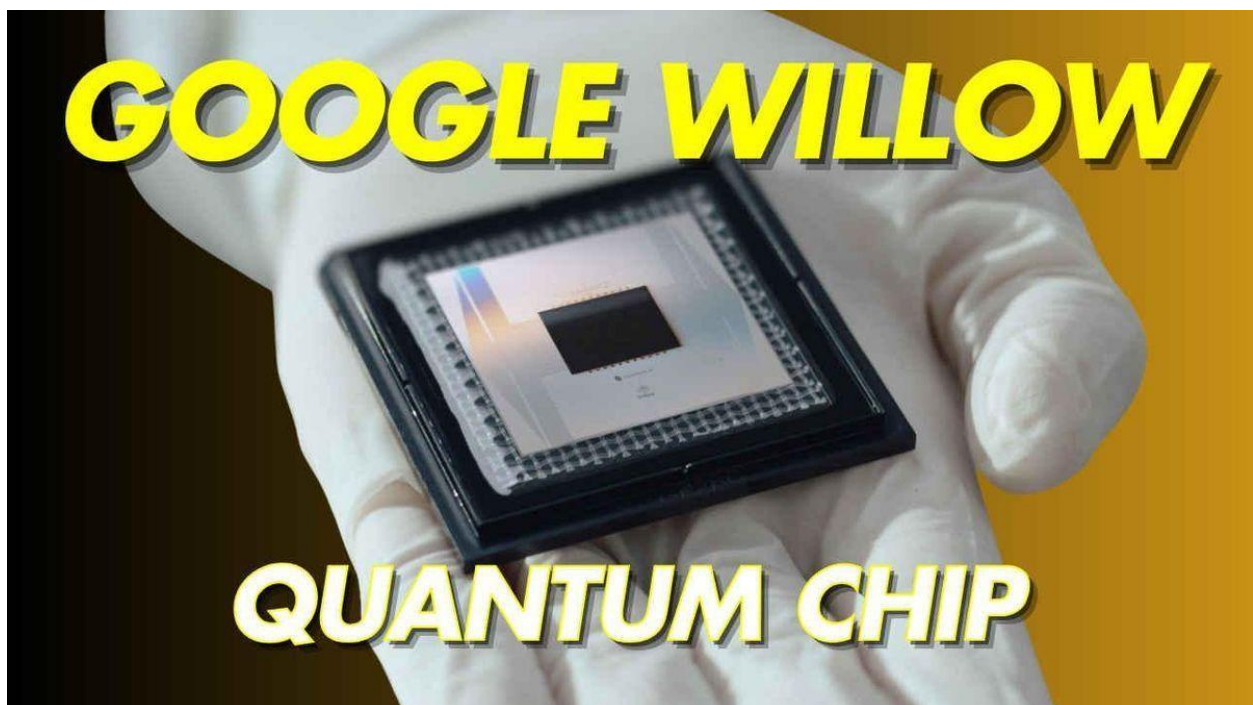
But it's not only American companies and universities trying to figure out how to mitigate the errors that have limited the possibilities of quantum computers. Over the last 15 years, Chinese physicists have undertaken an ambitious program aimed at making their country the world leader in quantum technologies. One estimate pegs China — which has invested over \$15 billion in the project — as a leader or near equal to the U.S. in this new realm of science. In 2023, results from experiments suggested that Chinese physicists were notching impressive achievements that may enable them to construct a quantum computer that could outpace those developed in the U.S.

The consequences of Chinese superiority in this realm would be seismic. The U.S.'s foremost adversary would then be able to crack the encryption Americans use every day for secure internet traffic and messaging, and which the U.S. government and its allies use to protect secret communications. One

organization projects that the world has a mere [six years](#) before this capacity exists. Other estimates insist that date is as far as 10 years away. But it is coming fast.

That means the U.S. has to get out ahead of this impending technology to forestall disastrous consequences in every realm of American life. In May 2022 the White House [announced plans](#) to prepare the nation for post-quantum encryption alongside efforts being undertaken by private companies like Apple and Google. But Congress failed to renew a landmark federal funding bill for quantum research and development in 2023. Meanwhile, China and European countries are not flinching at devoting billions to quantum.

Quantum computing breakthroughs in 2023 herald a bright future that will transform life and economics. Technology sits on the cusp of fulfilling Feynman's vision and understanding the world and universe unlike ever before. An error-correcting quantum computer would launch the second quantum revolution, and a race is on to preserve the U.S.'s leadership in science for one of the 21st century's most prized technologies. To win that race, the federal government needs to make a concerted push to sustain American preeminence in quantum computing and other quantum technologies like sensing. That's how the U.S. won the first quantum revolution and the stakes are too high not to learn from this past triumph.



Google's Quantum Chip Can Do in 5 Minutes What Would Take Other Computers 10 Septillion Years

Google's quantum computing division unveiled a new chip, dubbed Willow, that the tech giant says makes it infinitely faster and better than existing supercomputers.

The chip addresses two major problems with quantum computers as we know them today. First, Google claims Willow can reduce quantum computing errors "exponentially." Quantum computers, as Microsoft's Azure Quantum [explains](#), are more prone to errors than classical computers because they exist in fragile states.

And researchers believe that quantum computers need more qubits to be more powerful—but more qubits also means more errors. Tackling this error issue has long been one of the quantum computing sector's largest challenges—one Google may be able to tackle.

"The more qubits we use in Willow, the more we *reduce* errors, and the more quantum the system becomes," [writes](#) Google Quantum AI lead Hartmut Neven (a qubit is a basic unit of quantum information, and the building block for a quantum computer).

The Willow chip. (Credit: Google.)

"We tested ever-larger arrays of physical qubits, scaling up from a grid of 3x3 encoded qubits, to a grid of 5x5, to a grid of 7x7—and each time, using our latest advances in quantum error correction, we were able to cut the error rate in half. In other words, we achieved an exponential reduction in the error rate," Neven continued.

Google has been [working](#) on quantum chips for the past decade. Its latest Willow chip is so fast that it can complete a computation in less than five minutes that would take a leading supercomputer of today like the [Frontier](#) supercomputer in Tennessee 10 septillion years, or 10,000,000,000,000,000,000,000,000 years, which is technically older than the universe itself, according to the company.

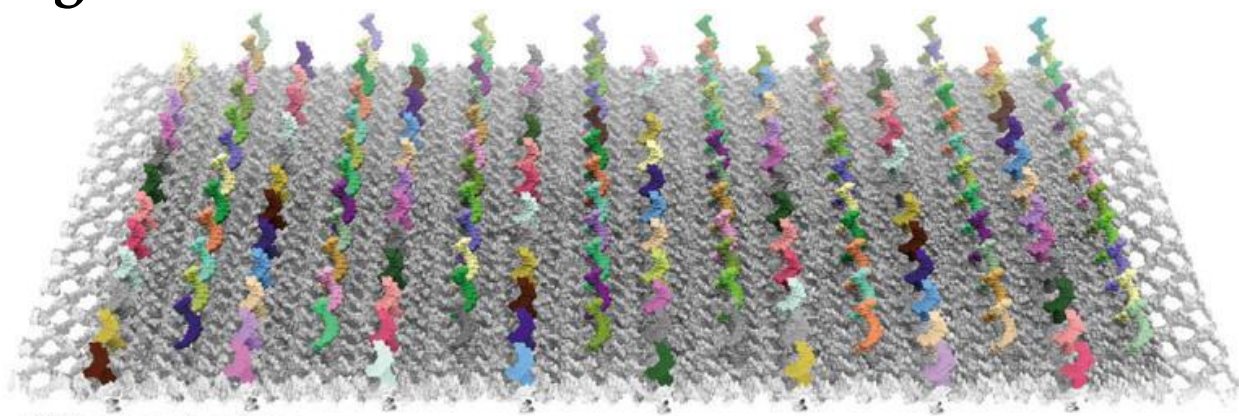
"It lends credence to the notion that quantum computation occurs in many parallel universes, in line with the idea that we live in a multiverse," Neven said, citing David Deutsch's prediction detailed in his 1997 book *The Fabric of Reality*.

In 2019, Google previously did a quantum computation in 200 seconds that would have taken the fastest supercomputer at that time 10,000 years. But IBM [dismissed](#) its claims, arguing that a classical computer could do the same calculation with greater "fidelity" in 2.5 days and argued that "quantum supremacy" had yet to be achieved.

While quantum computers are arguably still in their early stages, some researchers have already started to show how such machines might be able to disrupt our lives in the future—or potentially make them better. Chinese researchers have begun to [crack](#) military-grade with one machine, partly affirming a theory that quantum computers could eventually make present-day encryption methods obsolete.

But quantum computers could also help us better understand the universe, and could solve difficult computational problems. As the industry develops, some quantum firms are also looking to [establish manufacturing in North America](#) to ensure American and Canadian national security.

Fast, rewritable computing with DNA origami registers



DNA origami register

Folded, origami-like DNA attached to a glass surface, as shown in this illustration, store data for fast, rewritable DNA-based computation. Credit: Adapted from ACS Central Science 2024, DOI: 10.1021/acscentsci.4c01557

DNA stores the instructions for life and, along with enzymes and other molecules, computes everything from hair color to risk of developing diseases. Harnessing that prowess and immense storage capacity could lead to DNA-based computers that are faster and smaller than today's silicon-based versions.

As a step toward that goal, researchers [report](#) in *ACS Central Science* a fast, sequential DNA computing method that is also rewritable—just like current computers.

"DNA computing as a liquid computing paradigm has unique application scenarios and offers the potential for massive data storage and processing of digital files stored in DNA," says Fei Wang, a co-author of the study.

In living organisms, DNA expression occurs sequentially: Genes are transcribed into RNA, which is translated into proteins. This process happens to many genes simultaneously and repeatedly. If researchers can duplicate this complex, elegant dance in DNA-based computers, these devices could be more powerful than current silicon-based machines.

Researchers have demonstrated sequential DNA computing for very focused, specialized tasks. But until recently, not much progress had been made in developing more general and programmable DNA devices that could be used and reused for various applications.

In previous research, Chunhai Fan, Wang and colleagues developed a programmable DNA integrated circuit with many logic gates that act as instructions for the circuit's operations. Here's how it worked:

- Data, 0 or 1, was represented by a short piece of single-stranded DNA, called an oligonucleotide, that contained a series of bases: adenine, thymine, guanine and cytosine. (In nature, the sequence of bases codes for a gene.)

- For example, two inputs of 1 (DNA strands 1 and 2) would interact with an OR logic gate DNA molecule.
- Then in a fluid-filled tube, the input oligonucleotide interacted with a logic gate DNA molecule and generated an output oligonucleotide.
- The output oligonucleotide bound to a different single-stranded DNA that was folded into an origami-like structure, called a register in computer lingo.
- The oligonucleotide was "read" by reviewing its base sequence, released and used in a vial containing the next gate, and so on.

This process took hours, and someone had to manually transfer the oligonucleotide from one gate to another vial for the next computing operation. So the team, along with Hui Lv and Sisi Jia, wanted to speed things up.

To make the reaction processes more efficient and compact, the team first placed the DNA origami register onto a solid glass 2D surface. The output oligonucleotide floating in liquid from a specific logic gate then attached to the glass-mounted register.

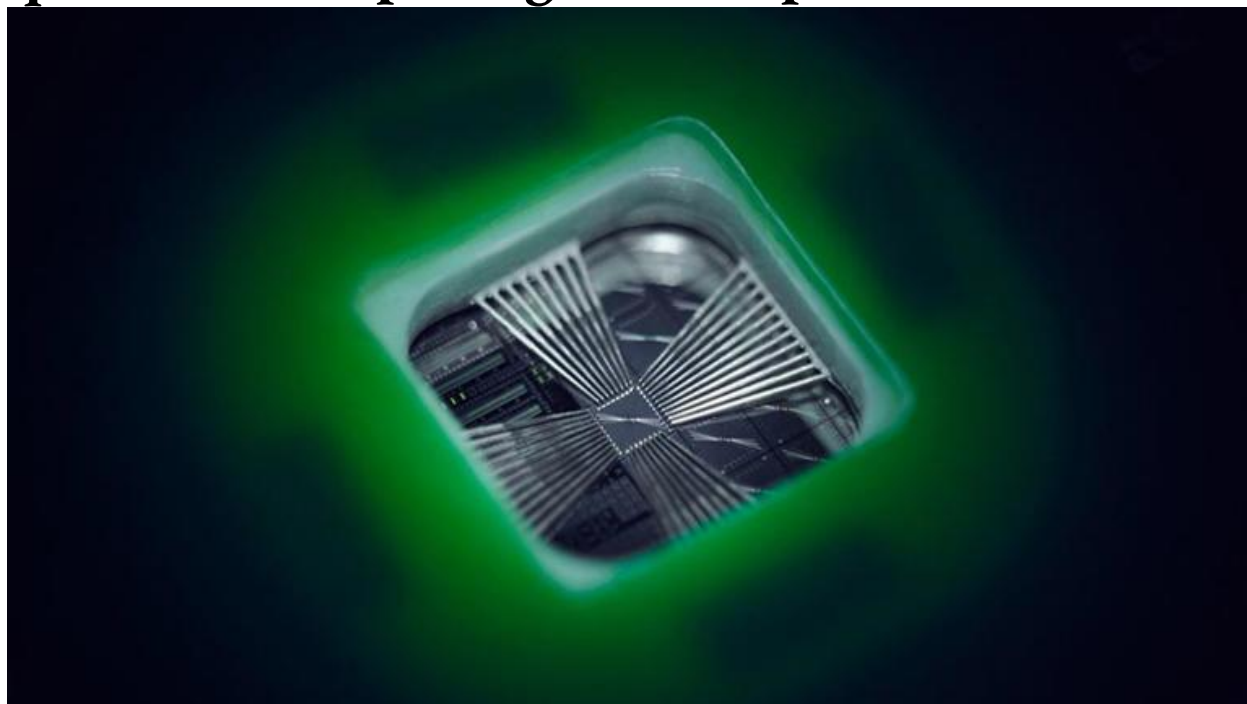
After the output oligonucleotide was read and the logic gate instructions determined, it detached, which reset the register so it could be rewritten, thereby avoiding the need to move or replace registers.

The researchers also designed an amplifier that boosted the output signal so all the pieces—the gates, oligonucleotides and registers—could find one another more easily. In a proof-of-concept experiment, all the DNA computing reactions took place in a single tube within 90 minutes.

"This research paves the way for developing large-scale DNA computing circuits with high speed and lays the foundation for visual debugging and automated execution of DNA molecular algorithms," says Wang.

More information: High-Speed Sequential DNA Computing Using a Solid-State DNA Origami Register, *ACS Central Science* (2024). [DOI: 10.1021/acscentsci.4c01557](https://doi.org/10.1021/acscentsci.4c01557). pubs.acs.org/doi/abs/10.1021/acscentsci.4c01557

"Something the world has never seen before" – revolutionary cryo-CMOS transistor thrives in freezing conditions; could be used for scaling quantum computing and in space tech



Something the world has never seen before" – revolutionary cryo-CMOS transistor thrives in freezing conditions; could be used for scaling quantum computing and in space tech© SemiQon

- **SemiQon announces first CMOS transistor for cryogenic conditions**
- **Engineered for extreme cold: operates efficiently at 1 Kelvin**
- **Transistor reduces heat dissipation 1,000x, consumes 0.1% usual power**

Heat is widely recognized as the enemy of sensitive electronic components, but ultra-low temperatures can also pose serious performance challenges.

Now, SemiQon, a Finland-based company focused on quantum computing hardware, has announced the development of what it describes as the first CMOS transistor fully optimized for cryogenic conditions.

The transistor is engineered to function effectively at temperatures as low as 1 Kelvin (-272.15°C or -457.87°F), just 1 degree above absolute zero, where most quantum computers operate. According to the company, this innovation addresses key challenges in scaling quantum computers while also being compatible with existing CMOS manufacturing processes, requiring no new infrastructure.

Space-borne applications

SemiQon says its transistor reduces heat dissipation by 1,000 times compared to conventional room-temperature transistors and consumes only 0.1% of the power. This allows control and readout electronics to be located inside a cryostat with the processors, eliminating heat dissipation problems that could disrupt the system. SemiQon believes this solution simplifies the growing complexity of managing quantum processors as their scale increases.

"It was clear to us and others in the scientific community, that a transistor which can operate efficiently at ultra-low temperatures would offer substantial value to users in the advanced computing sector and wherever these devices are required to function in cryogenic conditions," said Himadri Majumdar, CEO and Co-Founder of SemiQon.

"Our company is just 2 years old, and already we've delivered something which the world has never seen before. Our cryo-CMOS transistor will provide considerable advantages to users both in terms of CapEx and OpEx, as well as by enhancing the functionality of their hardware. This could potentially accelerate the development of quantum technologies, or even enable a new era of cryogenic electronics."

The transistor's potential extends beyond quantum computing to high-performance computing and space-borne applications. SemiQon also highlights

its impact on energy efficiency, noting that cooling costs for data centers are projected to grow significantly in the coming years.

SemiQon says it expects to deliver its first cryo-optimized CMOS transistors to customers in 2025. A short technical paper on the new transistor can be found on the [arXiv pre-print server](#).

Prediction: 2025 is the year quantum computing advances from physical qubits to logical qubits

published November 19, 2024

This transformative technology is poised to take a giant leap forward



(Image credit: Shutterstock / Phonlamai)

Quantum computing has long been a subject of fascination and excitement, promising to solve complex problems far beyond the capabilities of classical computers. As we enter 2025, this transformative technology is poised to take a giant leap forward, progressing from physical qubits to logical qubits. This shift marks a pivotal moment in the quantum industry's journey, one which sets the stage for exciting advancements across various industries and addresses the technical challenges that have, until now, constrained the potential of quantum computers.

Predicting the leap from physical to logical qubits

In a similar way that classical [computers](#) use bits to store information, quantum computers are built on the use of physical qubits to store quantum information. Unfortunately, physical qubits are sensitive to environmental noise, making them error-prone and unsuitable for solving large computational problems. This limitation can be overcome by using quantum error correction which encodes information across multiple physical qubits to create more reliable, error-resistant units called logical qubits. This transition will allow quantum computers to tackle real-world problems, moving the technology from experimental to practical, large-scale applications.

To effectively create many logical qubits, quantum computing hardware needs to incorporate multiple advanced technologies and algorithms and provide sufficient reliable computational resources in a sustainable way. Recent technical advances across the quantum industry, high-profile industrial partnerships, and an increasing number of scientists and engineers working on quantum error correction has accelerated the timeline to creating logical qubits much sooner than expected.

What the shift to logical qubits will enable

The transition to logical qubits in 2025 will dramatically enhance the capabilities of quantum computers, with far-reaching implications across multiple sectors.

Quantum chemistry is expected to be one of the first quantum computing applications to leverage logical qubits to simulate chemical reactions with much higher precision than classical computers. The first wave of studies will be highly scientific, but there will be a quick turning point to the exploration of real-world [applications](#) that will have tangible economic and societal value.

Another field which will benefit from the transition to logical qubits is renewable energy and battery development. By simulating physical quantum processes, such as the behavior of electrons in new materials, quantum computers will help accelerate the development of more efficient batteries and energy storage solutions. This could lead to breakthroughs in electric vehicles, renewable energy grids, and the quest for sustainable energy solutions.

The list of applications expands further as logical qubit counts and quality increase. For example, accelerated exploration of vast chemical spaces for potential drug identification for pharmaceutical applications, modeling of complex systems in the financial sector, optimizing interconnected supply chain problems for the manufacturing industry, modeling physical properties of new materials, and improving the performance of machine learning applications. All of these will be accelerated through the availability of logical qubits, allowing users to run deeper and more complex algorithms than before.

A new era of quantum computing emerges as Microsoft and Quantinuum partnership advances Logical Qubit development

published October 6, 2024

Quantum computing now more practical for real-world use



(Image credit: Shutterstock / Phonlamai)

[Microsoft](#) and Quantinuum claims to have made significant strides in the field of quantum computing through their a joint Azure Quantum project.

The companies say they have successfully created a new generation of highly reliable logical qubits, which are essential for achieving practical applications of quantum computing.

A few months ago, Microsoft and Quantinuum pioneered the creation of highly reliable logical qubits by applying Microsoft's qubit-virtualization system to Quantinuum's H-Series ion-trap qubits.

Azure Quantum

Initially, the companies managed to produce four logical qubits from 30 physical qubits. The logical error rate for the production was 800 times better than the physical error rate. Although Microsoft considered this feat as impressive, it kept pushing its boundaries and it paid off.

Now, the collaboration has expanded, resulting in the creation of 12 logical qubits from 56 physical qubits on Quantinuum's H2 machine, showcasing a remarkable 99.8% fidelity in two-qubit operations.

The teams demonstrated the entanglement of these logical qubits in a complex arrangement known as a Greenberger-Horne-Zeilinger (GHZ) state, which is more intricate than previous Bell state preparations. This entanglement resulted in a circuit error rate of 0.0011, significantly lower than the physical qubits' error rate of 0.024. Such advancements not only highlight the potential for deeper quantum computations but also pave the way for fault-tolerant quantum computing, a crucial step towards realizing the full capabilities of quantum technology.

The collaboration between Microsoft and Quantinuum is also a milestone in the application of quantum computing to real-world problems, particularly in the field of chemistry. By integrating logical qubits with [artificial intelligence](#) (AI) and cloud high-performance computing (HPC), they successfully tackled a complex scientific problem of estimating the ground state energy of an important catalytic intermediate.

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The process began with the identification of the active space of the catalyst through HPC simulations. Following this, the logical qubits were employed to simulate the quantum behaviour of the active space. The measurement outcomes from these simulations were then utilized to train an AI model, which ultimately provided an accurate estimate of the ground state energy. This end-to-end workflow represents the first instance where quantum computing, HPC, and AI have been combined to solve a scientific problem, demonstrating the practical utility of quantum technologies.

While the current results do not yet represent a full scientific quantum advantage—defined as the ability of quantum computers to solve problems beyond the reach of classical computers—they showcase the potential for quantum systems to outperform classical methods in specific scenarios. The hybrid approach employed in this study illustrates how quantum computing can enhance the accuracy of chemical computations, particularly for complex problems that are challenging for classical systems.

The successful demonstration of this hybrid workflow not only highlights the capabilities of the logical qubits but also emphasizes the importance of integrating quantum computing with other advanced technologies. By combining the strengths of quantum, AI, and HPC, researchers can develop innovative solutions to pressing scientific challenges.

The Azure Quantum platform serves as a central hub where quantum computing, AI, and high-performance computing (HPC) converge. This ecosystem is designed to facilitate seamless interactions between different hardware architectures, enabling researchers to leverage the strengths of each technology. By combining quantum capabilities with AI, researchers can utilize machine learning algorithms to analyze vast datasets and extract meaningful insights, significantly speeding up the research and development process.

Looking ahead, Microsoft claims that it is committed to advancing its Azure Quantum platform to support a variety of qubit architectures, including neutral-atom qubits and topological qubits. The integration of these diverse technologies aims to enhance the reliability and scalability of quantum computing, ultimately leading to the development of systems capable of addressing some of the world's most significant challenges.

"The ability of our systems to triple the number of logical qubits while less than doubling our physical qubits from 30 to 56 physical qubits is a testament to the high fidelities and all-to-all connectivity of our H-Series trapped-ion hardware," said Rajeeb Hazra, CEO of Quantinuum.

"Our current H2-1 hardware combined with Microsoft's qubit-virtualization system is bringing us and our customers fully into Level 2 resilient quantum computing. This powerful collaboration will unlock even greater advancements when combined with the cutting-edge AI and HPC tools delivered through Azure Quantum."

Google's 'Willow' chip aimed at leap in quantum computing



Quantum computers like the one here at the Leibniz Supercomputing Center can calculate much faster than other computers, but they also make many mistakes.© Sven Hoppe/dpa/picture alliance

In some scientific fields, such as data encryption, drug and materials research or machine learning and artificial intelligence, conventional or "classical" computers have reached their limits.

The calculations that researchers need in these fields are taking an infinitely long time to complete, or have become simply impossible.

That's why researchers around the world are working to tap into the enormous potential of quantum computers — they could solve mathematical problems much faster than the fastest conventional computers.

What is special about quantum computers?

The potential of current computing technology has been completely exhausted.

Computers work with bits that know only two states: 1 for "on" and 0 for "off".

[Quantum bits](#), also known as qubits, on the other hand, can assume an infinite number of states.

As a result, quantum computers [can calculate much faster](#), but are also more prone to errors.

"Disturbances from the outside, such as thermal radiation or noise from the electronics, or from the inside, such as material defects" can cause calculation errors, according to Stefan Filipp, a professor in quantum computing at the Technical University of Munich (TUM).

"Although these are now very small — one thousandth to one ten-thousandth of every operation goes wrong — they are not yet small enough [for quantum computers] to run sufficiently long algorithms, " says Filipp.

What has Google achieved with its 'Willow' chip?

The development of quantum computers is [still in its infancy](#). Researchers are currently working with 100 qubits of computing power. Soon there will be 10,000 qubits, and 10,000,000 qubits are also conceivable in the future.

But the systems that have been developed so far are too small and make too many mistakes to deliver any real value. And their error rate tends to increase with additional computing power.

Without a reliable way to correct such errors, quantum computers [will be useless in the real-world](#).

Markus Müller, Professor of Theoretical Quantum Technology at RWTH Aachen University, said the Google team succeeded for the first time in achieving quantum error correction with error rates below a recognized threshold.

That's led to their developing Willow. German computer scientist Hartmut Neven wrote in the journal Nature that with Willow, Google was paving the way for

quantum computing to become common. Neven is the founder and director of Google's Quantum Artificial Intelligence Laboratory.

Will quantum computers arrive soon?

The short answer is "no". While researchers in the field say Google has taken a significant step, Google concedes that Willow's error rate is still too high for quantum computing to be useful in an applied setting.

Willow consists of 105 superconducting qubits. That is less than 10% of the 1,457 physical qubits they say they need to achieve satisfactory error rates.

"In order to ultimately be able to calculate virtually error-free and thus reliably, the error correction rate must increase faster than the error rate," said Michael Hartmann, a professor of theoretical physics at the Friedrich Alexander University in Erlangen-Nürnberg.

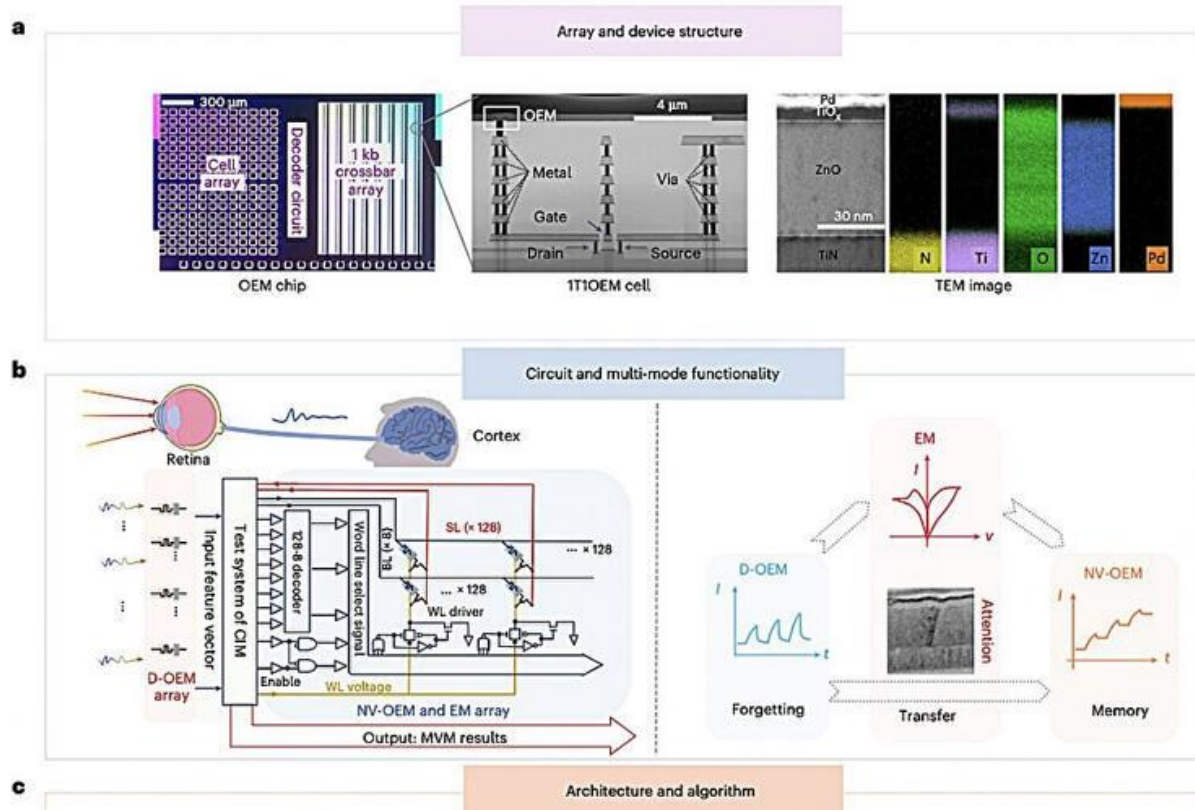
"With the current quality of qubits, you will need 100,000 to one million qubits to be able to perform large, fault-tolerant calculations," said Hartmann. This shows, he said, how far quantum computing still has to travel.

This article was translated from the original piece written in German

Source:

Neven H et al. (2024): Quantum error correction below the surface code threshold. Nature. DOI: 10.1038/s41586-024-08449-y.

Optoelectronic device mimics human vision for diversified in-sensor computing



OEM array and in-sensor computing system. Credit: Nature Nanotechnology (2024). DOI: 10.1038/s41565-024-01794-z

To make sense of the world, most humans rely in great part on their vision.

Recent research suggests that the human visual system is hierarchical, meaning that it processes information on different levels, ranging from the low-level processing of sensory stimuli to the high-level processing associated with more advanced cognitive abilities.

Computer scientists have recently been trying to develop systems that mimic the hierarchical structure of the human visual system to tackle different levels of information processing effectively. One proposed approach to achieve this is in-sensor computing, which entails the integration of sensing, memory and processing functions into a single device.

Researchers at Tsinghua University recently developed a new promising optoelectronic device for diversified in-sensor computing. This device, introduced in a paper [published](#) in *Nature Nanotechnology*, is based on a fully integrated array of optoelectronic memristors (OEMs), hardware components that can both process and store information.

"Large-scale monolithic integration of in-sensor computing based on emerging devices with complementary metal–oxide–semiconductor (CMOS) circuits remains challenging, lacking functional demonstrations at the hardware level," wrote Heyi Huang, Xiangpeng Liang and their colleagues in their paper.

"We report a fully integrated 1-kb array with 128×8 one-transistor one-optoelectronic memristor (OEM) cells and silicon CMOS circuits, which features configurable multi-mode functionality encompassing three different modes of electronic memristor, dynamic OEM and non-volatile OEM (NV-OEM)."

The device presented by the researchers leverages both electricity and light to concurrently process information and store data, which is essential for in-sensor computing applications. The OEMs have a layered structure with various materials (Pd/TiO_x/ZnO/TiN) placed on top of each other.

Notably, the team's fully integrated OEM array has different configurable modes of operation. These modes allow the system to mimic the human visual system's hierarchical information processing.

"These modes are configured by modulating the charge density within the oxygen vacancies via synergistic optical and electrical operations, as confirmed by differential phase-contrast scanning transmission electron microscopy," wrote Huang, Liang and their colleagues.

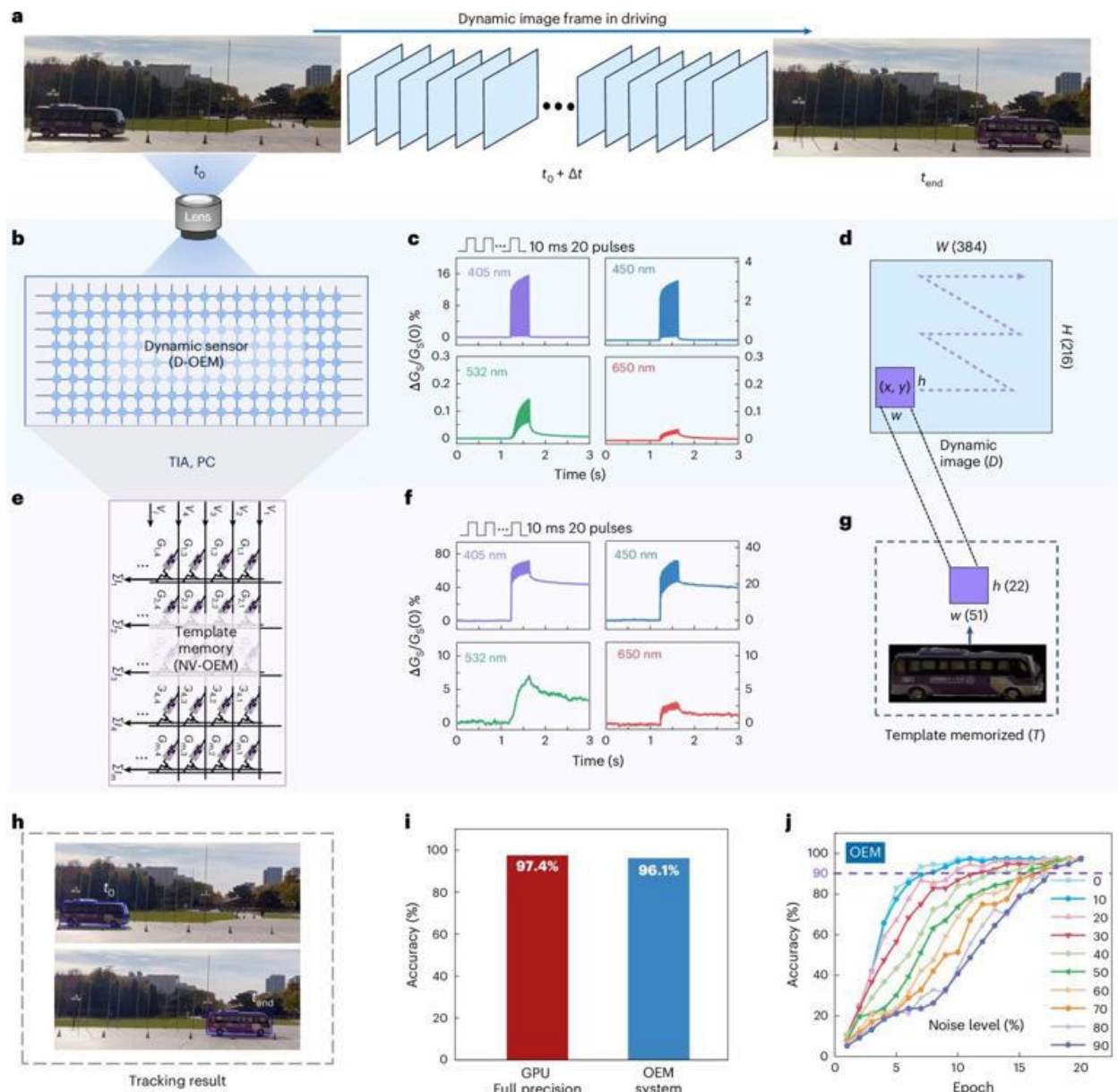
So far, the researchers have evaluated their OEM-based device in a series of initial experiments, using it to run computer vision algorithms. Their findings were highly promising, as the OEM array enabled good accuracies on all the three visual tasks it was tested on, while also consuming less power.

"Using this OEM system, three visual processing tasks are demonstrated: image sensory pre-processing with a recognition accuracy enhanced from 85.7% to 96.1% by the NV-OEM mode, more advanced object tracking with 96.1% accuracy using both dynamic OEM and NV-OEM modes and human motion

recognition with a fully OEM-based in-sensor reservoir computing system achieving 91.2% accuracy," wrote Huang, Liang and their colleagues.

"A system-level benchmark further shows that it consumes over 20 times less energy than graphics processing units."

The recent study by this team of researchers introduces a new cost-effective optoelectronic platform that could prove advantageous for the realization of a variety of in-sensor computing applications. As part of their next studies, Huang, Liang and their colleagues could further optimize the performance of their system, for instance by using transparent materials on the OEM's top electrode to increase their light absorption rate.



Object tracking by the hybrid D-OEM and NV-OEM sensory system. Credit: Nature Nanotechnology (2024). DOI: 10.1038/s41565-024-01794-z

More information: Heyi Huang et al, Fully integrated multi-mode optoelectronic memristor array for diversified in-sensor computing, *Nature Nanotechnology* (2024). DOI: [10.1038/s41565-024-01794-z](https://doi.org/10.1038/s41565-024-01794-z). www.nature.com/articles/s41565-024-01794-z

Light allows creation of quantum computers with ordinary displays and lasers

Quantum computers are extremely expensive to build, often costing millions of dollars due to the need for specialized materials, components, and equipment such as cryogenic systems and advanced electronics.

This is one of the reasons why scientists in only some developed parts of the world currently have access to this advanced computing technology.

However, a new study by researchers at the University of the Witwatersrand, Johannesburg (Wits University) proposes a quantum computer made with ordinary equipment.

This innovation has the potential to make powerful [quantum computing technology](#) more affordable and accessible to all.

It may sound unbelievable, but the study authors build a quantum computer using only laser beams, digital displays (like those found in projectors), and simple lenses. When they ran tests, their computer successfully performed complex tasks and processed multiple levels of information beyond the capabilities of classical computers.

The uncanny power of light

The quantum computer built by the researchers is [driven by the properties of light](#). They used a classically structured light, a type of light beam manipulated to have specific shapes, structures, or phases, enabling them to carry complex information.

By applying quantum principles, like state superposition (where a system can exist in multiple states at once), the researchers performed photonic matrix multiplication—a process where light patterns are used to perform mathematical operations with matrices.

“The key was linking how light interacts with optical devices, such as digital displays and lenses, to the mathematical operations that a quantum operation in a quantum computer performs,” the study authors [note](#).

Once the classically structured light was successfully integrated with the optical components of the computer, the researchers tested their quantum system using the Deutsch-Jozsa algorithm.

This particular algorithm addresses a specific problem; identifying whether a function is constant (producing the same output for all inputs) or balanced (giving different outputs for half of the inputs). It may sound simple but this algorithm reveals whether a system is faster, better, and more efficient than a [classical computer](#).

Analyzing the quantum computer’s performance

When the researchers tested their quantum computer, its performance surprised them because, similar to an expensive quantum system, their innovation [outperformed classical computers](#) by a significant margin.

While traditional computers work with only 0 and 1, “We’ve shown that our system can work with 16 different levels of information,” highlighted Mwezi Koni, lead researcher and an M.Sc. candidate at the Wits University.

“In theory, we could expand this to handle millions of levels, which would be a game-changer for processing complex information,” Koni added.

Moreover, since this quantum computer uses light to process information, the speed at which it can solve multiple complex calculations simultaneously is unmatched.

“Traditional computers work like switchboards, processing information as simple yes or no decisions. Our approach uses laser beams to process multiple possibilities simultaneously, dramatically increasing computing power,” Isaac Nape, one of the study authors and an expert in quantum technology at Wits, said.

The Wits team is hopeful that their innovation will increase access to [quantum computers](#) in labs and quantum research facilities located in countries that can't afford expensive quantum technologies.

The [study](#) is published in the journal *APL Photonics*.

New Shelly smart devices have one-mile range, thanks to Z-Wave



New Shelly smart devices have one-mile range, thanks to Z-Wave© PC World

Smart home devices compatible with the Matter standard have garnered most of our attention lately, but the compelling features in the latest generation of Z-

Wave chips convinced the IoT developer Shelly Group to build no fewer than 11 new products powered by Z-Wave technology.

The new collection includes a smart plug, in-wall dimmers, relays, and various sensors aimed at DIYers, installers, and commercial builders.

Citing the ability of Z-Wave 800 (aka Z-Wave Long Range or LR) chips to operate IoT devices over extremely long range—up to 1 mile, line of sight—while running on battery power for up to 10 years, Shelly Group CTO Leon Kralj said “Shelly is helping break down smart home connectivity barriers, empowering homeowners, security installers, and commercial property owners and managers with unmatched range, scalability, and energy efficiency to redefine their automation experience.”

While some of the new Shelly products, including the smart plug, motion sensor, and door/window sensor, will look familiar to any smart home dweller, Shelly takes a different approach to its in-wall lighting controls. Rather than wholesale replace your existing devices, as a Leviton or Lutron would have you do, Shelly’s dimmers and relays mount inside the electrical box and *behind* your existing device. Hiding the controls from view helps you avoid being left with a visual hodgepodge of dimmers and switches on your home’s walls.



Shelly

While most homeowners won't need to worry about the number of IoT devices their networks can support, commercial builders will appreciate the scalability of Z-Wave 800-powered devices—namely, you can deploy as many as 4,000 nodes on a single mesh network. That's a 20x increase over what was possible with previous generations of the chip. And since Z-Wave LR is backward compatible with those previous generations, there should be no worries about integrating the new devices into existing networks.

Shelly says all 11 of its new Z-Wave 800-powered IoT devices will be available in the first half of 2025.

Earlier this month, Shelly announced that it had attained SmartThings Certification for nine more of its existing Z-Wave smart home products, including power-metering smart plugs and smart switches.

While Samsung dropped the Z-Wave radio from its own most recent SmartThings hub, the [SmartThings Station](#), it is still supported as an option and can be found in the SmartThings-powered [Aeotec Smart Home Hub](#).

Latest Shelly smart devices have a one-mile range, thanks to Z-Wave

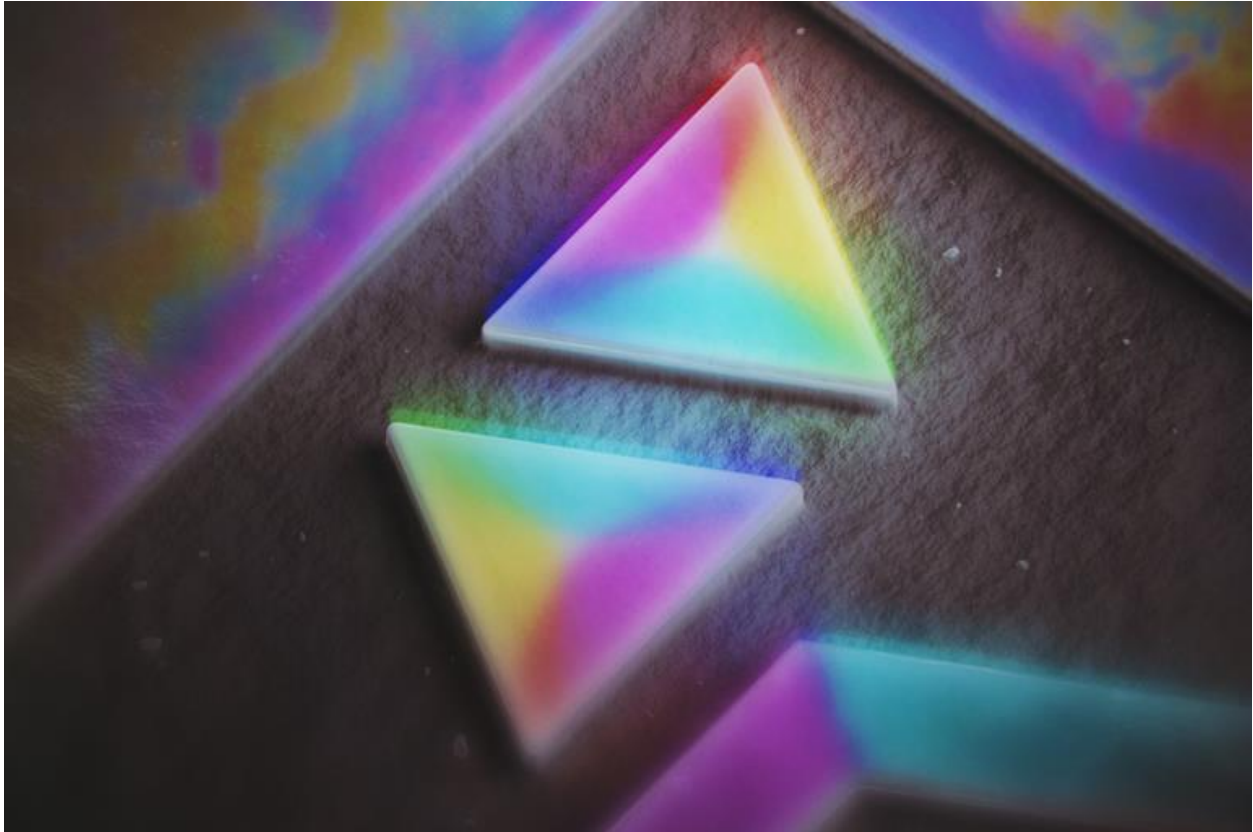
New Class of Magnets Promises To Supercharge Tech Speeds by 1000X

What's New

For the first time, scientists have imaged an entirely new form of [magnetism](#) called altermagnetism.

The researchers used cutting-edge x-ray techniques to visualize and fine-tune this novel magnetic material, which is very different from the kind of [magnets](#) we know in day-to-day life.

Their findings, published in *Nature*, demonstrate that altermagnetic materials can be precisely controlled in microscopic devices, marking a major step forward in magnetic and [material science](#).



The image shows an artist's impression of altermagnetic devices viewed through an electron microscope. The colourful overlay depicts the directional variation of the altermagnetism, both naturally in open space (top) and controlled by the edge of the devices (triangles), forming interesting magnetic textures. Alex Speed CC 4.0 BY© Alex Speed CC 4.0 BY

Why This Matters

Magnetic materials are integral to modern technology, particularly in data storage and microelectronics, but they come with challenges, including energy and memory inefficiency.

Altermagnetic materials offer a greener alternative while combining the best features of existing magnetic classes—ferromagnets and antiferromagnets.

These new materials could dramatically enhance device performance, potentially increasing microelectronic and digital memory speeds by up to a thousand times.

They also have the potential to advance fields like quantum computing, which is struggling to break free from highly specific applications in the lab.

Furthermore, this innovation could reduce dependency on toxic elements, significantly decreasing the carbon footprint of the electronics industry by increasing the energy efficiency of electronic devices.

What to Know

Ferromagnets, like the magnets commonly found on refrigerator doors, have all their magnetic moments aligned in the same direction, creating a strong external magnetic field.

In contrast, antiferromagnets feature alternating magnetic moments that cancel each other out at the macroscopic level, resulting in no external magnetic field—making materials of this kind ineffective for holding up your shopping list on the fridge.

Humans have known about ferromagnets for millennia, but antiferromagnets remained undiscovered until about a century ago.

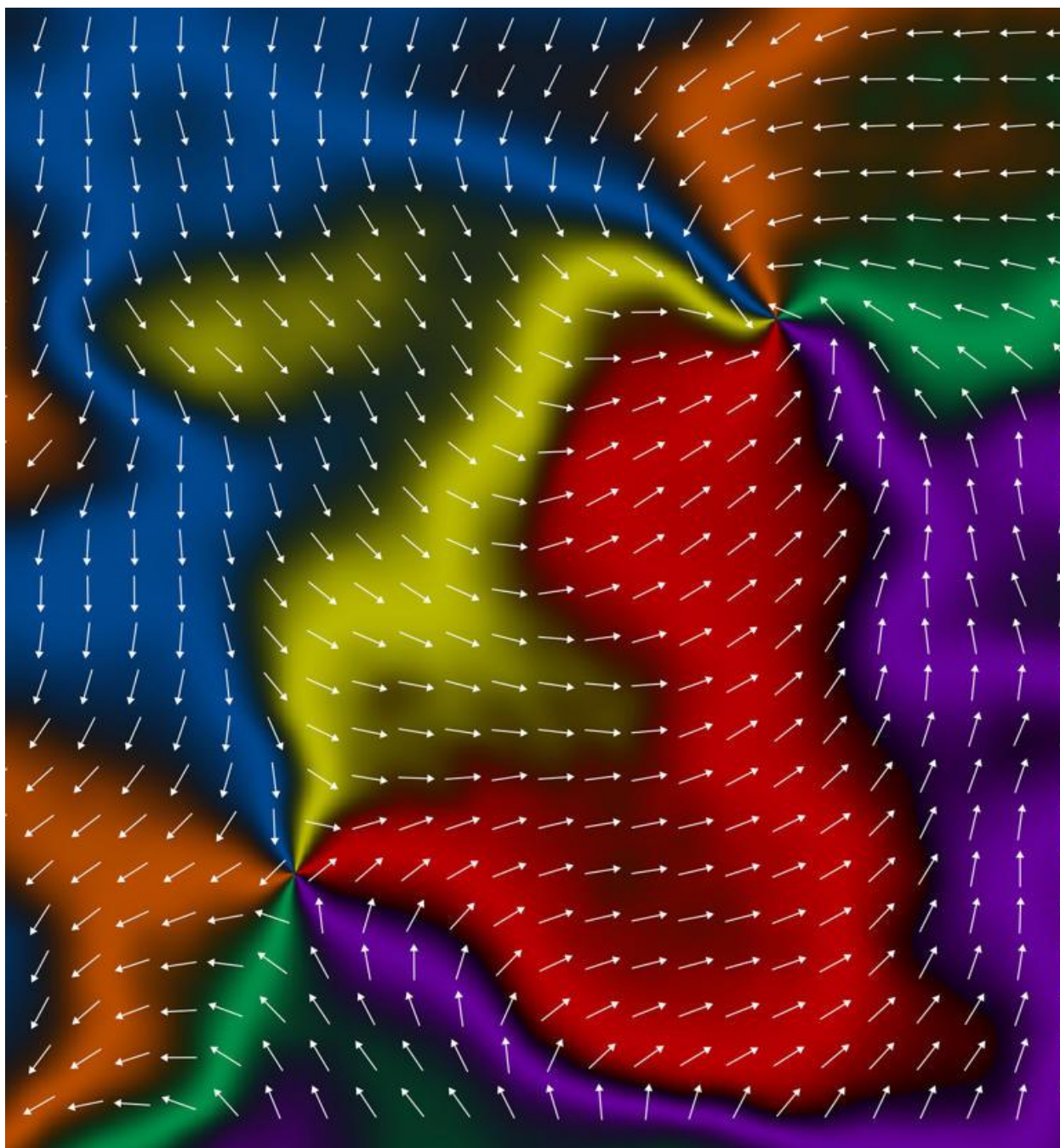
"They lay hidden for so long because, to all intents and purposes, they look like non-magnetic material," Peter Wadley, co-author of the study, told *Newsweek*.

But now there's a new kid on the block: altermagnets.

"Altermagnetism is a newly defined class of magnetic material in which the magnetism appears invisible, but the properties are well defined and measurable," Oliver Amin, lead author of the study, told *Newsweek*.

Like antiferromagnets, altermagnets have antiparallel magnetic moments, which means they lack a macroscopic magnetic field. Yet they also exhibit a feature of ferromagnetism called time-reversal symmetry breaking.

According to Amin, this combination allows altermagnets to unite the best traits of both magnetic classes, opening up potential for innovative applications in advanced electronic devices.



The image shows a microscopic map of altermagnetism within our material. Of interest are two swirling vortex textures that have potential use in next-generation devices. O. J. Amin et al.© O. J. Amin et al.

In this new study, the researchers showed that manganese telluride (MnTe) is a ferromagnet as predicted and imaged it on the nanoscale.

"This is the first time that we've used those properties to image an altermagnetic structure in great detail," Wadley said. "So this is the first time that it kind of

makes it real. Seeing is believing, and we can see that the altermagnetic order in reality is as predicted by theory."

But the team didn't stop there.

"To elevate this research, we showed that MnTe hosts interesting magnetic textures, and by making devices of certain shapes, we can choose exactly what textures form," Amin said. "This is a crucial step before making functional devices."

This is all very new to science—it was only earlier this year that [scientists reported experimental evidence of altermagnets](#)—and now this latest study has taken critical step forward, providing a blueprint for how these materials can be manipulated that others can work from.

From enhancing the performance of solid-state drives to enabling more efficient quantum computing, altermagnets could revolutionize how data is stored and processed.

The findings also highlight the potential for reduced material waste and energy use in electronics, making altermagnetic materials a promising avenue for sustainable technological progress.

What's Next

Next up for the team, Amin said, is to be able to use electrical currents to control the magnetic state of these materials: "That would be the next huge achievement, because that really is getting towards a proper functional device."

"As has been seen over the last year, interest in altermagnetism is taking off at an astonishing rate," he added. "With such an intense level of research in this field, I predict altermagnets will have a commercial impact within 5–10 years."

In the long run, Wadley believes that altermagnets could replace hard disk storage used in data centers across the globe. In the short term, he said to keep an eye out for more developments in the field in 2025.

He added, "I think that a lot will be coming in the next few years. It's probably the most vibrant area that I've seen in the 20 something years I've been doing research. I think there's a lot to come."

Quantum Computers Are Like Kaleidoscopes, Helping Illustrate Science and Technology

Quantum Computers Are Like Kaleidoscopes, Helping Illustrate Science and Technology© Provided by Discover Magazine

Quantum computing is like [Forrest Gump's box of chocolates](#): You never know what you're gonna get. Quantum phenomena – the behavior of matter and energy at the atomic and subatomic levels – are not definite, one thing or another. They are opaque clouds of possibility or, more precisely, probabilities. When someone observes a quantum system, it loses its quantum-ness and "collapses" into a definite state.

Quantum phenomena are mysterious and often counterintuitive. This makes quantum computing difficult to understand. People naturally reach for the familiar to attempt to explain the unfamiliar, and for quantum computing this usually means using traditional binary computing as a metaphor. But explaining quantum computing this way leads to major conceptual confusion, because at a base level the two are entirely different animals.

This problem highlights the often mistaken belief that common metaphors are more useful than exotic ones when explaining new technologies. Sometimes the opposite approach is more useful. The [freshness of the metaphor](#) should match the novelty of the discovery.

The uniqueness of quantum computers calls for an unusual metaphor. As a communications researcher [who studies technology](#), I believe that quantum computers can be better understood as kaleidoscopes.

Digital Certainty vs. Quantum Probabilities

The gap between understanding classical and quantum computers is a wide chasm. Classical computers store and process information via transistors, which are electronic devices that take binary, deterministic states: one or zero, yes or no. Quantum computers, in contrast, [handle information probabilistically](#) at the atomic and subatomic levels.

Classical computers use the flow of electricity to sequentially open and close gates to record or manipulate information. Information flows through circuits, triggering actions through a series of switches that record information as ones and zeros. Using binary math, bits are the foundation of all things digital, from the apps on your phone to the account records at your bank and the Wi-Fi signals bouncing around your home.

In contrast, quantum computers use changes in the quantum states of atoms, ions, electrons or photons. Quantum computers link, or entangle, multiple quantum particles so that changes to one affect all the others. They then introduce interference patterns, like multiple stones tossed into a pond at the same time. Some waves combine to create higher peaks, while some waves and troughs combine to cancel each other out. Carefully calibrated interference patterns [guide the quantum computer toward the solution](#) of a problem.

Achieving A Quantum Leap, Conceptually

The term "[bit](#)" is a metaphor. The word suggests that during calculations, a computer can break up large values into tiny ones – bits of information – which electronic devices such as transistors can more easily process.

Using metaphors like this has a cost, though. They are not perfect. Metaphors are incomplete comparisons that transfer knowledge from something people know well to something they are working to understand. The bit metaphor ignores that the binary method does not deal with many types of different bits at once, as common sense might suggest. Instead, all bits are the same.

The smallest unit of a quantum computer is called the quantum bit, or qubit. But transferring the bit metaphor to quantum computing is even less adequate than using it for classical computing. Transferring a metaphor from one use to another [blunts its effect](#).

The prevalent explanation of quantum computing is that while classical computers can store or process only a zero or one in a transistor or other computational unit, quantum computers supposedly store and handle both zero and one and other values in between at the same time through the process of [superposition](#).

Superposition, however, does not store one or zero or any other number simultaneously. There is only an expectation that the values might be zero or one at the end of the computation. This quantum probability is the polar opposite of the binary method of storing information.

Driven by quantum science's uncertainty principle, the probability that a qubit stores a one or zero is like [Schroedinger's cat](#), which can be either dead or alive, depending on when you observe it. But the two different values do not exist simultaneously during superposition. They exist only as probabilities, and an observer cannot determine when or how frequently those values existed before the observation ended the superposition.

Leaving behind these challenges to using traditional binary computing metaphors means embracing new metaphors to explain quantum computing.

Peering Into Kaleidoscopes

The kaleidoscope metaphor is particularly apt to explain quantum processes. Kaleidoscopes can create infinitely diverse yet orderly patterns using a limited number of colored glass beads, mirror-dividing walls and light. Rotating the kaleidoscope enhances the effect, generating an infinitely variable spectacle of fleeting colors and shapes.

The shapes not only change but can't be reversed. If you turn the kaleidoscope in the opposite direction, the imagery will generally remain the same, but the exact composition of each shape or even their structures will vary as the beads randomly mingle with each other. In other words, while the beads, light and mirrors could replicate some patterns shown before, these are never absolutely the same.

Using the kaleidoscope metaphor, the solution a quantum computer provides – the final pattern – depends on when you stop the computing process. Quantum

computing isn't about guessing the state of any given particle but using mathematical models of how the interaction among many particles in various states creates patterns, called quantum correlations.

Each final pattern is the answer to a problem posed to the quantum computer, and what you get in a quantum computing operation is a probability that a certain configuration will result.

New Metaphors For New Worlds

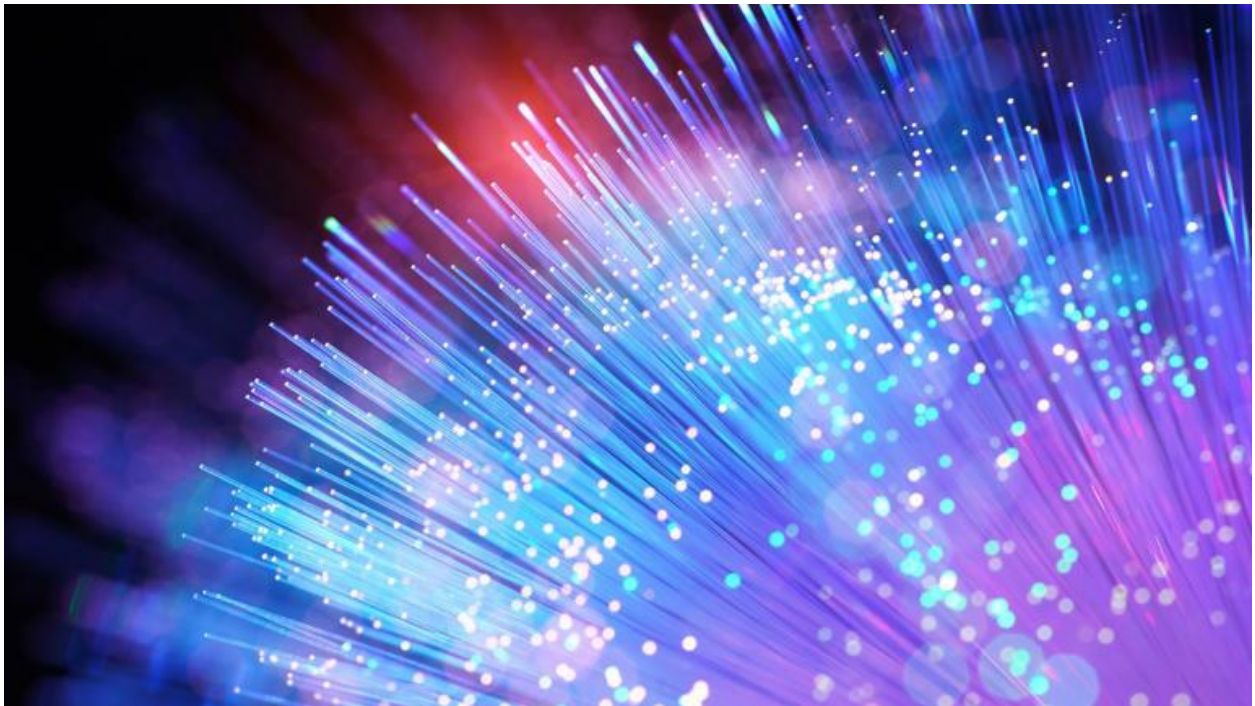
Metaphors make the unknown manageable, approachable and discoverable. Approximating the meaning of a surprising object or phenomenon by extending an existing metaphor is a method that is as old as calling the edge of an ax its "bit" and its flat end its "butt." The two metaphors take something we understand from everyday life very well, applying it to a technology that needs a specialized explanation of what it does. Calling the cutting edge of an ax a "bit" suggestively indicates what it does, adding the nuance that it changes the object it is applied to. When an ax shapes or splits a piece of wood, it takes a "bite" from it.

Metaphors, however, do much more than provide convenient labels and explanations of new processes. The words people use to describe new concepts change over time, expanding and taking on a life of their own.

When encountering dramatically different ideas, technologies or scientific phenomena, it's important to use fresh and striking terms as windows to open the mind and increase understanding. Scientists and engineers seeking to explain new concepts would do well to seek out originality and master metaphors – in other words, to think about words the way poets do.

[Sorin Adam Matei](#) is an Associate Dean for Research at Purdue University

Engineers enable quantum communication over existing fiber optic cables — new research shows data transmission using quantum teleportation is possible in parallel with a classical network at specific wavelengths



Engineers at [Northwestern University](https://www.northwestern.edu) have successfully achieved quantum communication in parallel with classical channels by identifying specific wavelengths with minimal interference from classical signals (Source: northwestern.edu). This breakthrough lays the groundwork for quantum communication by leveraging existing infrastructure and sending quantum data alongside classical data. The researchers managed quantum teleportation over a 30.2km fiber optic cable carrying 400 Gbps of classical traffic.

Quantum computing seems to be all the hype these days. Google claims its new [quantum chip](#) can solve problems swiftly, which classical computers would otherwise take, and I quote 10 billion years to do; that's 10, followed by 24 zeroes. Quantum entanglement is a phenomenon wherein two particles are linked so that their quantum states (spin, polarization, energy levels, etc.) are connected, regardless of the physical distance. When measuring the state of one particle, the entanglement collapses, revealing the correlated state of the other particle. However, this does not allow for FTL (Faster Than Light) communication in line with the no communication theorem.

Enter Quantum teleportation. This concept combines entanglement with a classical channel, such as the Internet, and is the backbone of this research. It transfers one particle's quantum state to another located elsewhere.

Jordan Thomas, one of the research paper's authors, underlined the essence of quantum teleportation; "By performing a destructive measurement on two photons — one carrying a quantum state and one entangled with another photon — the quantum state is transferred onto the remaining photon, which can be very far away." A key point to understand here is that the photons aren't transmitted physically. Instead, information encoded within their quantum states is what is sent.

The primary concern with a worldwide network employing quantum teleportation is compatibility; will quantum communication work over classical channels? The likelihood of interference is exceptionally high among the billions of photons being sent concurrently in a fiber optic cable. The research discovered specific wavelengths where the density of classical photons was lower, making such wavelengths suitable for the photons in quantum teleportation. Bell state measurement, or simply state measurement, is performed at the mid-point of the cable. Coupled with other methods to reduce noise and interference, this method can potentially support multiple TB/s of classical data alongside quantum communication.

While it may take years or decades before quantum communication goes mainstream, Prem Kumar, the head of the research team, has high hopes for the future. Based on the current roadmap, the next major milestones are using two

pairs of entangled photons instead of one and scaling this experiment to real-world optical fiber networks.

Scientist says human consciousness comes from another dimension

A baffling new [theory to explain human consciousness](#) has suggested it comes from hidden dimensions and is not just brain activity.

A physicist claimed that we plug in to these invisible planes of the universe when making art, practicing science, pondering philosophy or dreaming, and this could explain the phenomenon that has evaded scientific understanding for centuries.

Michael Pravica, a professor of physics at the University of [Nevada, Las Vegas](#), has based the wild idea on hyperdimensionality, the idea that the universe is made up of more dimensions than just the four we perceive: height, length width and time. But his theory is highly controversial, with one scientist saying that the cornerstone of Pravica's theory 'borders on science fiction.'



Physicist Michael Pravica believes that human consciousness transcend the physical world and move between hidden dimensions

'The sheer fact that we can conceive of higher dimensions than four within our mind, within our mathematics, is a gift... it's something that transcends biology,'

Scientists have been attempting to explain human consciousness and its origins for hundreds of years - and the theories run the gamut.

One leading theory suggests that consciousness is related to how much information is integrated between the different parts of the brain. The more information is connected and integrated, the more conscious a being is thought to be.

Another posits that conscious mental states are driven by top-down signaling in the brain. Top-down signaling refers to the process by which higher-level brain regions send information, expectations or context to lower-level brain regions.

But Pravica's theory ventures outside the realm of neuroscience and into theoretical physics.

He suggested that in moments of heightened awareness, like when we enter a dream state or use our brains for deeply creative or intellectual tasks, our consciousness could transcend our physical dimension and enter a higher plane.

In these moments, our consciousness syncs with hidden dimensions and receives a flood of inspiration, Pravica said.

To better understand the controversial theory, consider the following scenario.

Imagine you're a two-dimensional being living in a two-dimensional world, like a character in a comic book. Now, imagine that a sphere passes through your plane of view.

The sphere would look like a dot that grows into a larger and larger circle as it comes closer, then gradually shrinks until it's out of view. You would have no way of knowing that it's actually a three-dimensional shape.

Pravica sees us as a version of these 2D characters. Although we exist in a four-dimensional world, we can only perceive matter and energy that is of those four dimensions, just like how beings in a 2D world cannot perceive a 3D object.

Thus, the limitations of our world prevent us from detecting higher dimensions that could, in theory, exist all around us.

This is the foundation of hyperdimensionality - the idea that the universe is made up of many dimensions, some of which are hidden because they are beyond the reach of our physical realm.

Hyperdimensionality ties into string theory, which states that reality is made up of infinitely small vibrating strings that are smaller than atoms, electrons or quarks.

As the strings vibrate, twist and fold, they produce effects in multiple unseen dimensions that give rise to all the particles and forces that we can observe, from particle physics to gravity.

'String theory is essentially a theory of hyperdimensionality,' Pravica said. 'It's looking at how the universe is put together on a sub-quantum scale.'



Pravica believes that our brains can tap into higher dimensions when in a dream state or performing deeply creative or intellectual tasks

Although we can observe the effects that these vibrating strings have on the physics of our dimension, we can't observe the hidden dimensions that they're vibrating in.

That is - we can't physically observe them.

But our consciousness may be able to tap into them, Pravica says.

Hyperdimensionality and string theory are widely accepted by physicists, but Pravica's idea of their relationship with consciousness is more controversial - especially because it blurs the lines between science and spirituality.

As an Orthodox Christian with a Ph.D. from Harvard, Pravica has found hyperdimensionality to be a way to bridge his scientific background with his religious beliefs.

For example, he believes Jesus may be a hyperdimensional being.

'According to the Bible, Jesus ascended into heaven 40 days after being on Earth. How do you ascend into heaven if you're a four-dimensional creature?' Pravica asked.

But being hyperdimensional could, theoretically, have allowed Jesus to move between our world and heaven - which may be a world of higher or infinite dimensions, he said.

Pravica's theory is based on a 'God of the gaps' perspective, where gaps in scientific knowledge are explained by divine intervention, said Stephen Holler, associate professor of physics at Fordham University.

He believes that this type of thinking is insufficient, and hampers the scientific inquiry needed to truly understand and explain ineffable phenomena like human consciousness.

'It's a poor explanation mechanism that arguably stifles the inquisitive nature required for good science and teaches that it's not okay to say, 'I don't know,'" Holler told Popular Mechanics.

He points out that our ability to mathematically manipulate higher dimensions is not proof that they actually exist, or that our consciousness can interact with them.

What's more, exploring these higher dimensions is impossible due to the limitations of our current technological capabilities.

Not even the most powerful particle accelerator in the world - the Large Hadron Collider (LHC) at CERN - can provide real proof that these dimensions exist.

The LHC smashes particles together at incredibly high speeds - up to the speed of light.

This allows physicists to study the fundamental building blocks of matter and energy and access infinitesimally small dimensions - even smaller than a single proton.

But even the LHC isn't able to reveal the high-dimensional strings that quantum physics predicts. To get that granular, physicists would need a much more powerful collider.

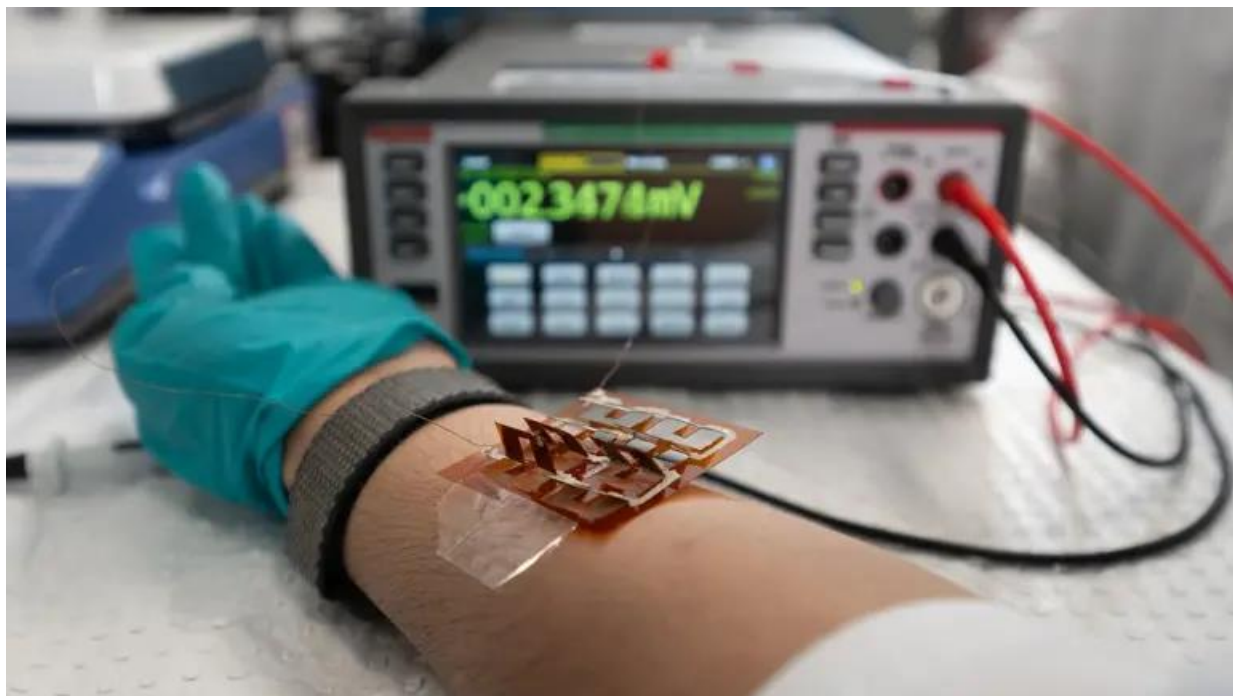
Without that concrete evidence, Holler says that hyperdimensionality 'borders on science fiction.'

But Pravica is optimistic that such technology could exist within his children's lifetime.

Until then, he will continue to support hyperdimensionality and his theory of how it relates to our consciousness.

'I see no point otherwise,' he said. 'Why study? Why live?'

Body Heat Could Power Next Generation of Wearable Devices, Marking New Battery Era



Body Heat Could Power Next Generation of Wearable Devices, Marking New Battery Era

Why it matters: Scientists have developed flexible thermoelectric devices that convert body heat into electricity, potentially eliminating the need for traditional batteries in wearable technology. As reported by [PopSci](#), this breakthrough comes as the global battery industry undergoes massive transformation to meet growing energy storage demands.

The Big Picture: According to [The Hustle](#), researchers at Queensland University of Technology and the [University of Washington](#) have created innovative materials that harness body heat:

- Uses nanobinder crystals and bismuth telluride sheets
- Generates enough power to run LED lights
- Enables battery-free medical devices
- Creates self-powered smart clothing

Healthcare Applications: The technology could revolutionize medical devices:

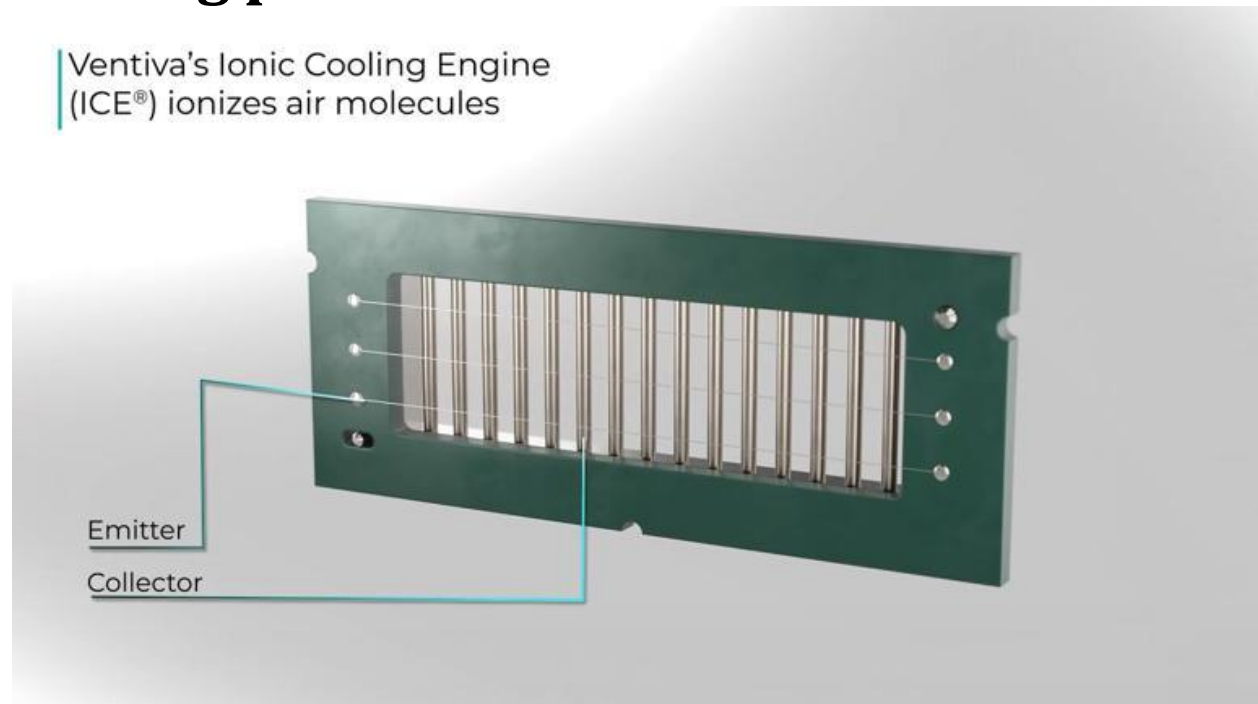
- Continuous glucose monitoring without battery changes
- Self-powered pacemakers
- Uninterrupted health tracking
- Enhanced patient comfort and safety

Broader Energy Transition: This development coincides with massive growth in battery technology:

- Lead-acid battery market projected to reach \$59 billion by 2032
- Electric car registrations hit 14 million globally in 2023
- Lithium-ion battery demand growing at 15.5% annually
- Battery costs declining through economies of scale

Looking Forward: The technology could expand beyond wearables to cool data centers and power virtual reality systems, marking a significant step toward sustainable electronics like the [best smart watches](#) and reduced environmental impact.

Fan-less cooling solution for laptops up to 40W launched — device uses movement of ions to generate airflow without any moving parts



Fan-less cooling solution for laptops up to 40W launched — device uses movement of ions to generate airflow without any moving parts© Ventiva

Ventiva has just launched its innovative ICE9 thermal management suite that works completely silently and without any moving parts. It will launch with devices packing up to 25W processors at CES in a few days, but it is expected to be able to cool partner laptop designs up to 40 watts TDP by 2027.

According to [Ventiva](#) (PDF), ICE9 uses the firm's Ionic Cooling Engine (ICE), which allows it to cool electronic devices without any moving parts. This device is claimed to be [far more efficient than the Frore AirJet](#) solid-state active cooling released a couple of years ago, although it's still slightly less efficient than an actual fan.

However, what makes Ventiva's ICE9 thermal management suite better than the typical fan is its completely silent operation and ultra-compact form factor, with a

device height of just 12 mm. This makes it the ideal solution for thin-and-light laptops, allowing OEMs to use relatively high-powered processors while preventing thermal throttling. So, aside from letting laptop makers build sleek devices, it could also allow them to insert additional components to extend the function of their device, like Framework's dual M.2 module that slots in the empty space between the fan of its Framework Laptop 16 Expansion Bay.

Continue reading

"Our ICE technology is transforming the electronics market, enabling a new wave of silent, intelligent heat-transferring thermal management solutions, and our latest results underscore the remarkable scalability of our ICE9 solution," said Ventiva CEO Carl Schlachte. "Initially demonstrated within the 'thin and light' category of laptops at around 15W TDP, the ICE9 device now enables laptop manufacturers to extend these benefits to higher performance systems, paving the way for the launch of entire product families of silent computing products."

The company says that it has ICE9 solutions that can accommodate as much as 25 watts TDP right now, meaning it could handle some of the new breed of low-power and highly efficient processors from AMD and Intel, as well as Qualcomm's Snapdragon X chips. However, it's also working with OEMs to develop cooling solutions that could handle as much as 40 watts TDP, allowing it to easily handle some of the latest AI processors from Intel and AMD. Moreover, it is open to partners leveraging 'hybrid' solutions mixing ICE9 and fan(s) for ultra-quiet computing.

While Ventiva is currently focusing on laptops for the ICE9's application, it can also be used in a variety of other devices, like smartphones and tablets, especially given its particularly small size. However, it does have one weakness — the ICE9 has such low static pressure that OEMs cannot just drop it in in their current designs if they want to maximize the technology's cooling performance. Instead, they need to think about a hybrid solution or build a case specifically designed for the product that allows them to transfer heat efficiently from all heat-generating parts of the laptop so that the ICE9 can cool it directly, instead of relying on the airflow that a typical fan would generate. If laptop makers can solve this problem, we should be prepared to see impressive steps made in silent computing performance.

Ventiva's Ionic Cooling Engine has no fans but is quieter, higher performance, and more efficient than Frore AirJet according to TechTuber teaser

Tech enthusiast Dave2D has drawn the IT community's attention to an intriguing up-and-coming laptop cooler company, [Ventiva](#). Through its Ionic Cooling Engine (ICE) solid-state cooling technology, Ventiva could be set to revolutionize laptop cooling, and early testing results shared by Dave2D seem extremely promising. Like other solid-state coolers (which are a pre-existing technology but incredibly limited in application for reasons soon to become clear), Ventiva uses ionic thrusters to repel heat/push "air" without the use of a fan's moving parts with its ICE solid-state cooling technology.

The major issue with ionic coolers, and why they haven't seen widespread adoption before now, is that they're much more fragile to dust and debris than regular old fans are. While fans can obviously be hampered by dust, ionic coolers can be completely disrupted even by small amounts of foreign material, making them remarkably difficult to use for long-term scenarios, especially when existing fan-based coolers are so much cheaper and reliable.

That said, Ventiva also claims to have met and overcome these issues, though the specifics of how are apparently too patented to share with Dave2D or the wider public. Its official About page assures that all of its products are validated for "Pressure & Flow Generated (CFM)", "Silence (dbA, noise levels)", "RFI / EMI Immunity", "Humidity & Dust Immunity", and "In-System Lifespan".

These claims are given further weight by both a privately shown test unit laptop that Dave2D witnessed using a Ventiva cooler and a test box used in the video. Dave noted that while the demo laptop was apparently performing quite well with it, the far different nature of these cooling designs will require more custom laptop building work to make the *real* potential of solid-state laptop cooling come to light and offset its static pressure weaknesses.

COOLING PERFORMANCE

	Laptop Fan	Frere AirJet	Ventiva ICE
CFM / Watt	1.3 - 1.5 CFM	0.21 CFM	1.0 CFM
Noise @ Load	40 dB	25 dB	13 dB *
Heat Dissipation / Watt	~ 10 W	~ 5 W	~ 9 W

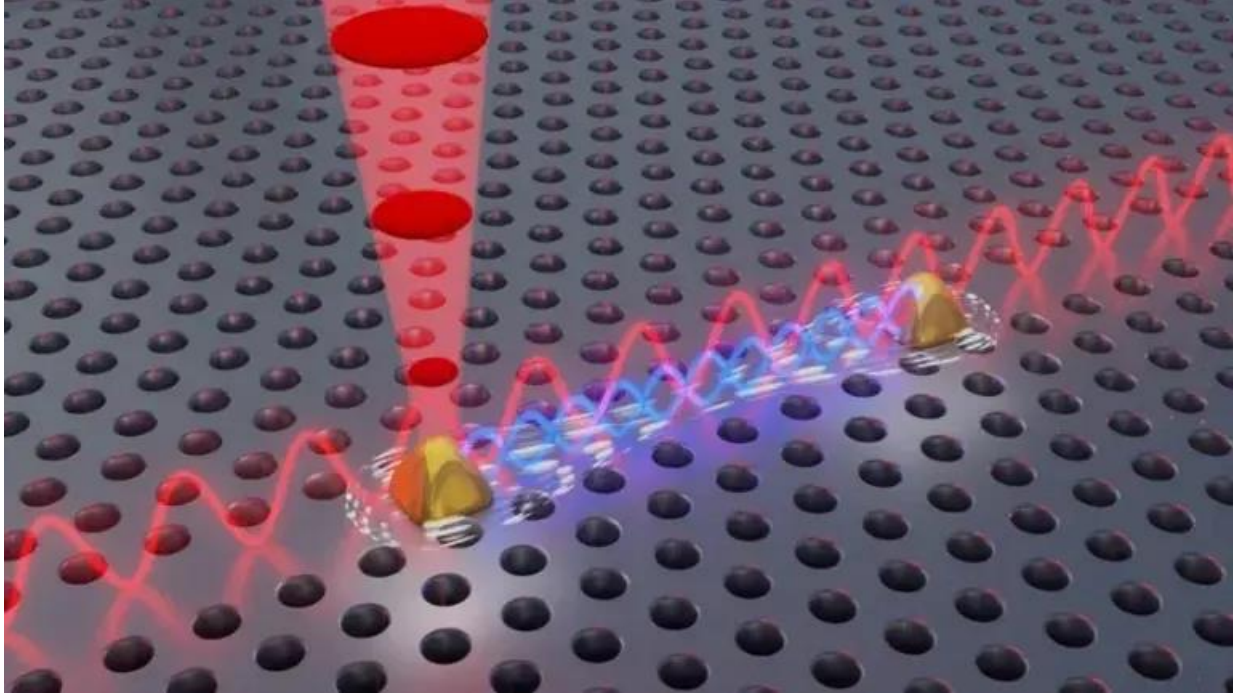
*sound of air flow through demo box (the device itself is silent)

((Image credit: Dave2D on YouTube))

In terms of raw cooling performance and noise levels, though, the Ventiva ICE certainly seems to have potential. Please reference the table above to gain insight into Ventiva's qualities and strengths.

We will ultimately have to wait and see if laptop manufacturers step up to the plate to build around this technology — and this technology in more retail products — to truly determine its value, though. The idea of a future with truly silent or near-silent (in the case of the hybrid designs) solid-state laptop cooling certainly intrigues, but we aren't quite there yet. However, Dave2D hints that we will see an important Ventiva partner emerge at CES 2025.

Danish researchers redefine quantum mechanics with major discovery



A persistent challenge in quantum research has been overcome by scientists at the [University of Copenhagen](#) in collaboration with [Ruhr University Bochum](#). They have successfully achieved control over two quantum light sources simultaneously—a feat previously limited to just one.

This breakthrough might appear modest to those outside the realm of quantum mechanics, but it marks a pivotal moment in the field. By enabling the creation of [quantum mechanical entanglement](#), this advancement opens the door to transformative commercial technologies.

The ability to control two quantum light sources is a cornerstone of quantum physics. Stable quantum light sources and the realization of entanglement—where two light sources can influence each other instantaneously, even across vast distances—are critical for building quantum networks. Entanglement underpins the development of efficient quantum computers and next-generation encryption methods.

Part of the team behind the invention. From left: Peter Lodahl, Anders Sørensen, Vasiliki Angelopoulou, Ying Wang, Alexey Tiranov, Cornelis van Diepen. (CREDIT: Ola J. Joensen)© The Brighter Side of News

The findings, recently published in [journal Science](#) by researchers at the Niels Bohr Institute, highlight the significant implications of this advancement.

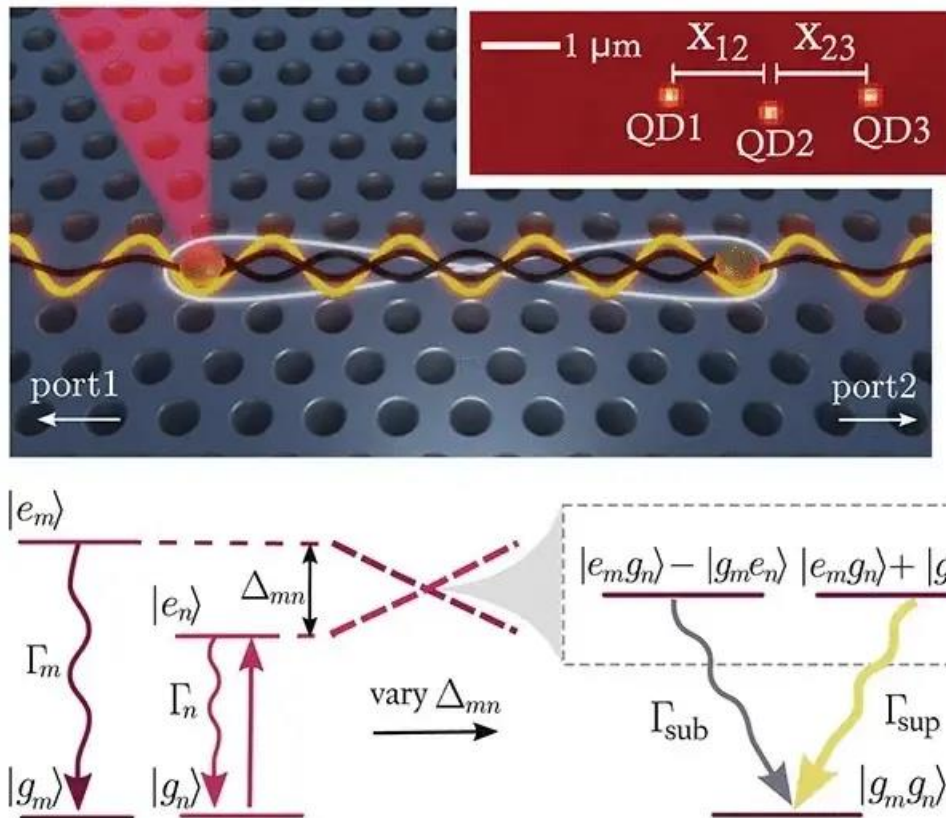
Professor Peter Lodahl, one of the lead researchers, emphasized that this achievement represents a major step toward the practical application of quantum technologies, including quantum computing, secure encryption, and an entirely new internet framework.

"We can now control two [quantum light sources](#) and connect them. It might not sound like much, but it's a major advancement and builds upon the past 20 years of work. By doing so, we've revealed the key to scaling up the technology, which is crucial for the most groundbreaking of quantum hardware applications," says Professor Lodahl, who has been researching in this area since 2001.

This innovation happens on a nanochip, barely larger than a human hair, developed by the researchers over recent years.

Professor Lodahl's group focuses on quantum technology using photons, light particles, to transport quantum information. Despite being a leader in this field, they could only control one light source at a time until now due to the sensitivity of these sources to external noise. The new research has succeeded in creating two identical [quantum light sources](#).

"Entanglement means that by controlling one light source, you immediately affect the other. This makes it possible to create a whole network of entangled quantum light sources, all of which interact with one another, and which you can get to perform [quantum bit operations](#) in the same way as bits in a regular computer, only much more powerfully," explains postdoc Alexey Tiranov, the lead author of the article.

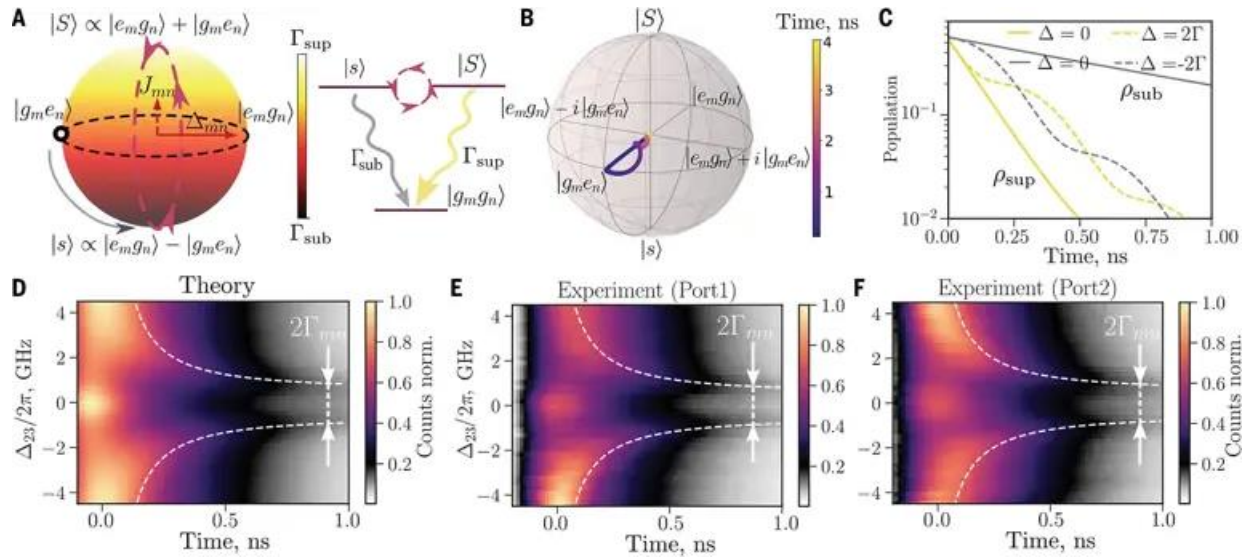


Collective super- and subradiant dynamics between distant optical quantum emitters. (CREDIT: Science)© The Brighter Side of News

A quantum bit can be both a 1 and 0 simultaneously, leading to processing power far beyond today's computer technology. According to Professor Lodahl, 100 photons from a single [quantum light source](#) contain more information than the world's largest supercomputer can process.

Using 20-30 entangled quantum light sources could potentially build a universal error-corrected quantum computer—the ultimate "holy grail" of quantum technology. Large IT companies are investing billions in this pursuit.

The biggest challenge was moving from controlling one to two quantum light sources, which required developing extremely quiet nanochips and precise control over each light source. Now, with this breakthrough, the fundamental [quantum physics research](#) is established. The task now is for other entities to build upon this work and apply quantum physics to technologies like computers, the internet, and encryption.

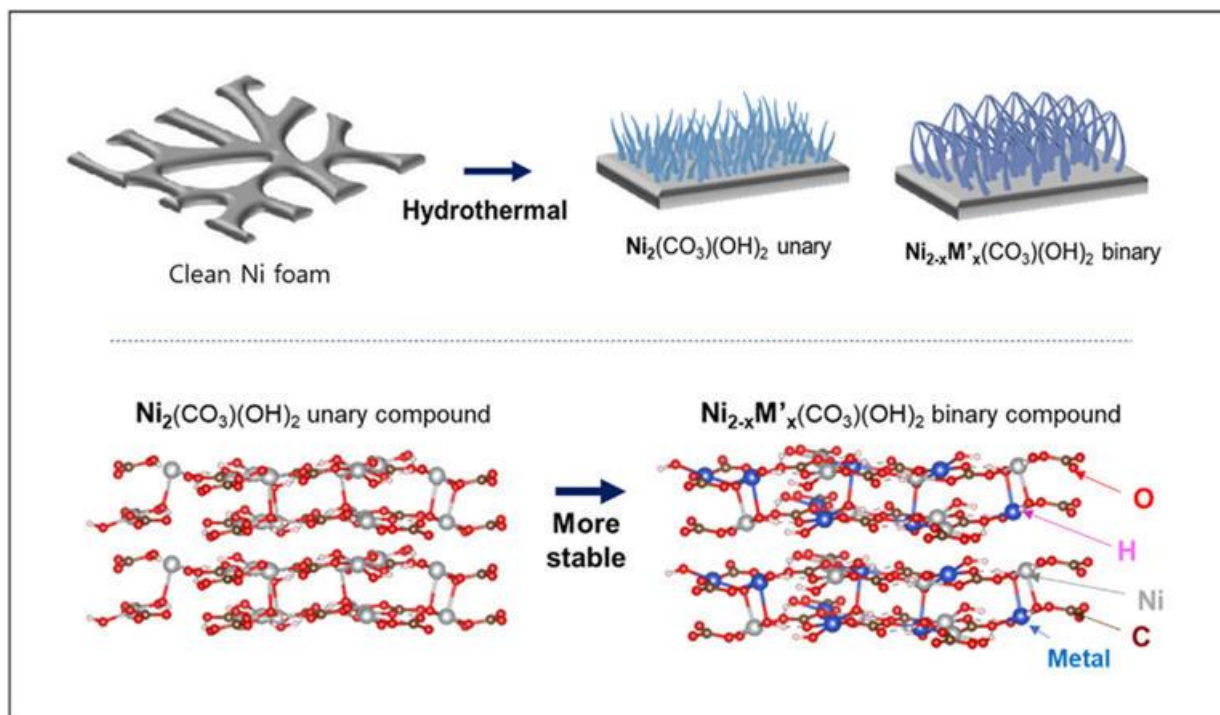


Photon emission is the hallmark of light-matter interaction and the foundation of photonic quantum science. (CREDIT: Science)

"It is too expensive for a university to build a setup where we control 15-20 quantum light sources. So, now that we have contributed to understanding the [fundamental quantum physics](#) and taken the first step along the way, scaling up further is very much a technological task," says Professor Lodahl.

The research was conducted at the Danish National Research Foundation's "Center of Excellence for Hybrid Quantum Networks (Hy-Q)" and is a collaboration between Ruhr University Bochum in Germany and the University of Copenhagen's Niels Bohr Institute.

First self-charging supercapacitors developed: Storage device capable of storing solar energy efficiently



Graphical abstract. Schematic diagram and atomic structure of $\text{Ni}_2(\text{CO}_3)(\text{OH})_2$ unary compound and $\text{Ni}_{2-x}\text{M}'_x(\text{CO}_3)(\text{OH})_2$ binary compound. Credit: Energy (2024). DOI: 10.1016/j.energy.2024.133593

A joint research effort has developed a high-performance self-charging energy storage device capable of efficiently storing solar energy. The research team has dramatically improved the performance of existing supercapacitor devices by utilizing transition metal-based electrode materials and proposed a new energy storage technology that combines supercapacitors with solar cells.

The paper is [published](#) in the journal *Energy*.

The research team designed the electrodes using a nickel-based carbonate and hydroxide composite material and maximized the conductivity and stability of the electrodes by adding transition metal ions such as Mn, Co, Cu, Fe, and Zn. This technology has greatly improved the performance of energy storage devices, demonstrating significant advancements in energy density, power density, and charge and discharge stability.

Particularly, the energy density achieved in this study is 35.5 Wh kg^{-1} , which is significantly higher than the energy storage per unit weight in previous studies ($5\text{-}20 \text{ Wh kg}^{-1}$). The power density is 2555.6 W kg^{-1} , significantly exceeding the values from previous studies ($\sim 1000 \text{ W kg}^{-1}$), demonstrating the ability to release higher power rapidly, enabling immediate energy supply even for high-power devices. Additionally, the performance showed minimal degradation during repeated charge and discharge cycles, confirming the long-term usability of the device.

Furthermore, the research team developed an energy storage device that combines silicon solar cells with supercapacitors, creating a system capable of storing solar energy and utilizing it in real time. This system achieved an energy storage efficiency of 63% and an overall efficiency of 5.17%, effectively validating the potential for commercializing the self-charging energy storage device.

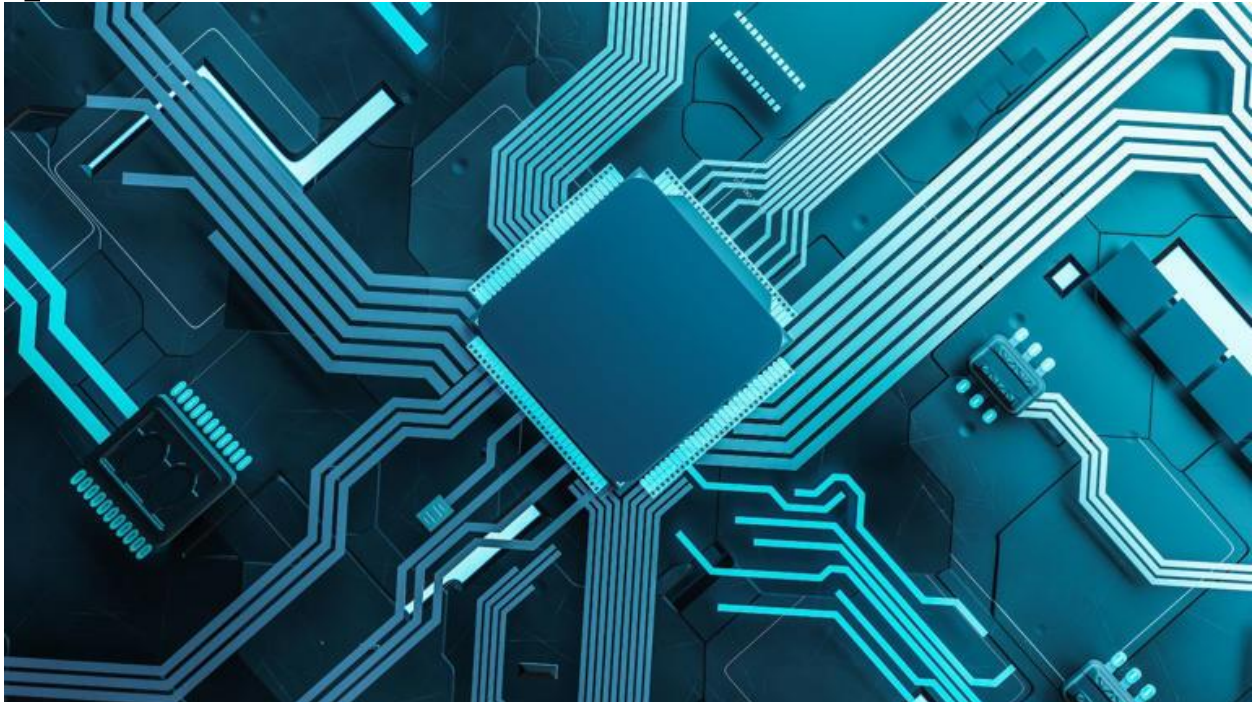
Jeongmin Kim, Senior Researcher at the Nanotechnology Division of DGIST, states, "This study is a significant achievement, as it marks the development of Korea's first self-charging energy storage device combining supercapacitors with solar cells. By utilizing transition metal-based composite materials, we have overcome the limitations of energy storage devices and presented a sustainable energy solution."

Damin Lee, a researcher at the RLRC of Kyungpook National University, stated, "We will continue to conduct follow-up research to further improve the efficiency of the self-charging device and enhance its potential for commercialization."

More information: Damin Lee et al, Design of high-performance binary carbonate/hydroxide Ni-based supercapacitors for photo-storage systems, *Energy* (2024). DOI: [10.1016/j.energy.2024.133593](https://doi.org/10.1016/j.energy.2024.133593)

Provided by Daegu Gyeongbuk Institute of Science and Technology

Quantum computers that are actually useful 1 step closer thanks to new silicon processor that could pack millions of qubits



Scientists say they have reached "a critical inflection point" after developing a technology that makes silicon-based quantum processors more viable.

Quantum computing company Equal1 has created a quantum processing unit (QPU) that can be built using conventional semiconductor manufacturing processes. This negates the complexity and expense typically involved with producing quantum processors using exotic materials or complicated techniques.

The company has also developed what representatives called "the most complex quantum controller chip developed to date." This can operate at ultra-low temperatures and paves the way for millions of qubits on a single chip — meaning it can handle a huge number of quantum bits of information simultaneously while keeping them stable and accurate for calculations.

By contrast, the most powerful quantum chips today only house qubits in the thousands and are built with superconductors, all requiring cooling to near absolute zero in order to perform quantum computations.

Combined, the new technologies "pave the way for the next phase of [quantum computing](#) and demonstrate the fastest way to scaling is to leverage existing silicon infrastructure," Equal1 representatives said in a [statement](#).

Quantum impracticalities

Building quantum chips is a notoriously difficult and expensive process. Unlike regular computer chips, which rely on binary bits to process information as 1s or 0s, quantum chips use [qubits](#), which are grounded in the principles of [quantum mechanics](#).

Qubits have special properties that allow them to exist in multiple states simultaneously — a phenomenon called superposition — and to work together in ways traditional bits cannot through a process called [entanglement](#). The resultant parallel processing enables quantum computers to solve problems far beyond the capabilities of classical systems.

However, qubits are incredibly fragile. They only work when they are kept in a state of coherence, meaning they maintain their quantum state long enough to perform calculations. Coherence is easily disrupted by environmental factors like temperature changes or electromagnetic noise — hence the need for extremely low temperatures, to avoid interference.

Typically, quantum chips are also made using exotic or custom-built materials like superconducting metals, which require expensive and complex manufacturing processes. Equal1's innovation is its use of silicon — one of the most abundant and widely used materials in the semiconductor industry.

Silicon provides a stable environment for qubits, particularly when using a material blend called [silicon germanium \(SiGe\)](#). In a study published Dec. 2 to the preprint database [arXiv](#), Equal1 scientists explained that SiGe combines silicon's stability with germanium's ability to enhance electronic performance, making it well-suited for quantum applications. More importantly, SiGe chips can be produced using the same processes and factories that are already used to

manufacture traditional computer chips, potentially making quantum processors [cheaper and easier to scale](#).

Equal1 representatives said its SiGe 6-qubit array — which is the part of the chip where qubits are created and controlled — had broken ground in two key areas: the precision of quantum gate operations and the speed at which those operations are performed.

Specifically, the chip demonstrated a single-qubit gate fidelity of 99.4% with an operation speed of 84 nanoseconds and a two-qubit gate fidelity of 98.4% with a speed of 72 nanoseconds. High accuracy, or fidelity, in quantum gates minimizes errors in calculations, while faster gate speeds reduce the risk of qubits losing their quantum properties during operations. These factors [determine the accuracy of quantum computations](#) and the ability of qubits to maintain their quantum states long enough to complete complex operations.

"This result demonstrates the massive benefit of silicon qubits — the ability to achieve the performance required for scaling in two key areas — fidelity and speed of quantum gates." Nodar Samkharadze, chief quantum architect at Equal1, said in the statement.

Putting a spin on it

To ensure reliable quantum operations, Equal1's device uses "spin qubits." Spin qubits encode information in [the spin state of an electron](#). In their study, the scientists said spin qubits are particularly well-suited for integration with silicon because silicon provides a stable environment for electron spins. This reduces the risk of qubits losing their delicate quantum properties due to interference from their surroundings.

Equal1 also developed a quantum controller chip that uses a multi-tile architecture; this design divides a chip into multiple tiles that can operate semi-independently. This architecture is key to scaling quantum systems because it allows control functions to be distributed across the chip, avoiding the bottlenecks that can occur when relying on a single processing unit.

The controller operates at 300 millikelvin — a temperature just above [absolute zero](#) — which allows it to effectively manage qubits while maintaining the

conditions needed for coherence. Equal1 representatives said the controller also features artificial intelligence (AI)-driven error correction technology, enabling real-time adjustments that maintain the stability and accuracy of quantum operations.

"Today marks a critical inflection point for Equal1 and the quantum computing industry," added Elena Blokhina, the company's chief scientific officer, in the statement. "Equal1 has always believed that silicon is the vehicle to scale quantum computers and today, with these world leading qubit and control chip results, we have taken a major step towards this vision."

Will we ever have quantum laptops?

published November 4, 2024

Quantum computers are here. But could we ever build a quantum laptop?



Will quantum computers ever be as small as laptops? (Image credit: s-c-s via Getty Images)

Roughly 80 years ago, the world was at war. Under a shroud of secrecy, scientists in the U.K., Germany and the U.S. were creating the first electronic computers. These computers filled rooms, demanded vast quantities of electricity and enabled previously impossible calculations. Few of the people involved could have imagined that decades later, computers orders of magnitude more powerful would fit in a backpack — yet that's exactly what happened.

So, as we sit on the threshold of genuinely useful [quantum computing](#), could we ever see quantum laptops? "I think it's possible," [Mario Gely](#), a quantum computing researcher at the University of Oxford, told Live Science. "It's highly speculative, but I can't think of a fundamental reason why a quantum laptop would not be possible."

Here are some of the steps that will be needed to get there.

Scaling up qubit number

Before scientists can make a quantum laptop, they need to make a useful quantum computer, period. Questions remain over how many [qubits](#) — quantum equivalents to digital bits — are needed to create a genuinely useful quantum computer, or one that can solve a range of useful, real-world problems that elude [the best superclassical computers](#). But it's definitely higher than is currently possible.

[Stephen Bartlett](#), a theoretical quantum physicist and director of the University of Sydney's Nano Institute, thinks we could see genuinely useful quantum computers by the end of this decade. "There's a bunch of open scientific challenges, which makes that pathway a bit murky, but we're getting close," Bartlett told Live Science.

Related: [What is the largest known prime number?](#)

For instance, newly developed quantum [charge-coupled device \(QCCD\) architecture](#) could be used to make two-dimensional arrays of qubits rather than one-dimensional ones — which would increase the density, and potentially the number, of qubits.

Reducing the errors in quantum computers

But scaling brings another challenge in building a miniature quantum computer: correcting errors, or "noise." "Our existing quantum components are noisy, so we need error correction, and that necessitates a large amount of redundancy," Bartlett said. Scientists need to either reduce errors or build error correction into quantum computers, and that requires even more qubits. Many scientists are trying to solve this problem.

For example, a [December 2023 study](#) tried to reduce errors by building a quantum computer with "logical qubits." In [another paper](#), published in April 2024, scientists designed a new type of qubit that behaved like an error-correcting logical qubit. Some scientists have even proposed using photons (light particles) as qubits, including [another study](#) that used a laser pulse. According to Peter van Loock, a professor of theoretical quantum optics at Johannes Gutenberg University of Mainz in Germany and co-author of the study, this approach has an "inherent capacity to correct errors". So if, within a decade or two, powerful and useful quantum computers exist, the next step would be miniaturization.



Will quantum computers ever look like laptops? (Image credit: Aitor Diago via Getty Images)

Choosing different types of qubits

But to get really small, quantum computers may need to focus on a different type of qubit than is currently popular. Some of the most advanced quantum computers today — such as those made by IBM and Google — rely on [quantum processing units](#) filled with superconducting qubits. But the first quantum laptop probably won't use this technology. That's because, by their nature, superconducting qubits must be cooled to a fraction above [absolute zero](#) — around 20 millikelvin — and that requires filling a room with dilution refrigerators. And companies like IBM aren't trying to get around this size constraint. For example, IBM's current [quantum computing roadmap](#) sets out goals that include a 2,000-qubit quantum computer by 2033 — which would fill many rooms rather than one.

Quantum laptops may instead rely on trapped ion qubits, charged particles that exist in multiple states at once and that are suspended using electromagnetic fields, Bartlett and Gely explained. Although trapped ion systems work at room temperature and don't rely on room-sized refrigerators, the lasers they use are gigantic.

"At the moment, our laser system occupies approximately a cubic meter [35 cubic feet]," Gely said. "If we assume that ion traps are the future, then we need the lasers to become smaller."

And lasers must not only shrink but also become more advanced. Current systems are geared to constrain 100 ions. "How many qubits you can control with this volume of laser equipment is unclear," Gely said. "You can control more qubits than we have today, but certainly not the millions of qubits of a fully fledged quantum computer."

However, two recent advances could help with miniaturization. First, future QCCDs could aid miniaturization by increasing qubit density. Second, in July, Stanford researchers created [titanium-sapphire lasers that are 10,000 times smaller](#) than the ones they replace.

Related: [How does a secure phone line work?](#)

Miniaturization efforts will ramp up

Right now, scientists are focused on making quantum computers more powerful, not on shrinking them. "The drive for miniaturization is not as strong at the moment as the drive for performance, and that mimics the early days of conventional computers when we had mainframes," Bartlett said. "People thought of the most powerful computers as taking up a building. And you know, why would anyone seriously consider carrying one around in your backpack?"

The [history of computers](#) suggests quantum computers will roll out first for industrial, military and government applications before shifting to consumers. The apocryphal 1943 quote from [Thomas Watson Sr.](#) that there would be a "world market for maybe five computers" springs to mind.

Of course, the world market for PCs and laptops is immense, so could there ever be a similar explosion of demand for quantum PCs and laptops? "The question I always get in my quantum computing classes is, you know, 'When can I play Doom on a quantum

computer?" Bartlett said. "But why would you want to when you can play Doom perfectly well on your computer today?"

Instead, Bartlett suggested there might be "quantum personal apps like finance or something niche around information security" — but the truth is, nobody knows. Gely made the alternative suggestion of a quantum processor sitting alongside a classical processor. "It could be like you have a graphics card, but it would only be useful for certain tasks," Gely said.

It's not yet clear that quantum laptops would be useful for consumers. What experts can say with a high level of confidence is that all of the hardware obstacles — scaling the number of qubits, correcting errors and miniaturizing components — can be overcome. And yet, a future quantum laptop probably won't play Doom.

New quantum computer smashes 'quantum supremacy' record by a factor of 100 — and it consumes 30,000 times less power

published July 11, 2024

The 56-qubit H2-1 computer has broken the previous record in the 'quantum supremacy' benchmark first set by Google in 2019.

When you purchase through links on our site, we may earn an affiliate commission. [Here's how it works.](#)

Scientists achieved an XMB score of 0.35, which means the H2 quantum computer can produce results without producing an error 35% of the time (Image credit: credit Quantinuum)

A new quantum computer has broken a world record in "quantum supremacy," topping the performance of benchmarking set by Google's Sycamore machine by 100-fold.

Using the new 56-qubit H2-1 computer, scientists at quantum computing company Quantinuum ran various experiments to benchmark the machine's performance levels and the quality of the qubits used. They published their results June 4 in a study uploaded to the preprint database [arXiv](#). The study has not been peer-reviewed yet.

To demonstrate the potential of the quantum computer, the scientists at Quantinuum used a well-known algorithm to measure how noisy, or error-prone, qubits were.

[Quantum computers](#) can perform calculations in parallel thanks to the laws of [quantum mechanics](#) and [entanglement](#) between qubits, meaning the fates of different qubits can instantly change each other. Classical computers, by contrast, can work only in sequence.

Adding more qubits to a system also scales up the power of a machine exponentially; scientists predict that quantum computers will one day perform complex calculations in seconds that a classical supercomputer would have taken thousands of years to solve.

The point where quantum computers overtake classical ones is known as "quantum supremacy," but achieving this milestone in a practical way would need a [quantum computer with millions of qubits](#). The largest machine today has only [about 1,000 qubits](#). The reason we would need so many qubits for "quantum supremacy" is that they are inherently prone to error, so many would be needed to correct those errors. That's why many researchers are now focusing on building more reliable qubits, rather than simply adding more qubits to machines.

When quantum computers overtake classical ones is known as "quantum supremacy," but achieving this milestone would need a [quantum computer with millions of qubits](#). (Image credit: credit Quantinuum)

The team tested the fidelity of H2-1's output using what's known as the linear cross entropy benchmark (XEB). XEB spits out results between 0 (none of the output is error-free) and 1 (completely error-free), Quantinuum representatives said in a [statement](#). Scientists at Google [first tested the company's Sycamore quantum computer using XEB](#) in 2019, demonstrating that it could complete a calculation in 200 seconds that would have taken the most powerful supercomputer at the time 10,000 years to finish. They registered an XEB result of approximately 0.002 with the 53 superconducting qubits built into Sycamore.

But in the new study, Quantinuum scientists — in partnership with JPMorgan, Caltech and Argonne National Laboratory — achieved an XEB score of approximately 0.35. This means the H2 quantum computer can produce results without producing an error 35% of the time.

"We are entirely focused on the path to universal fault tolerant quantum computers," [Ilyas Khan](#), chief product officer at Quantinuum and founder of Cambridge Quantum Computing, said in the statement. "This objective has not changed, but what has changed in the past few months is clear evidence of the advances that have been made possible due to the work and the investment that has been made over many, many years."

Quantinuum previously collaborated with Microsoft to demonstrate "logical qubits" that had an [error rate 800 times lower than physical qubits](#).

In the study, published in April, scientists demonstrated they could run experiments with the logical qubits with an error rate of just 1 in 100,000 — which is much stronger than the 1-in-100 error rate of physical qubits, [Microsoft representatives said](#).

"These results show that whilst the full benefits of fault tolerant quantum computers have not changed in nature, they may be reachable earlier than was originally expected," added Khan.

History of quantum computing: 12 key moments that shaped the future of computers

published September 30, 2024

Although quantum computing is a nascent field, there are plenty of key moments that defined it over the last few decades as scientists strive to create machines that can solve impossible problems.



(Image credit: Getty Images/[Bartłomiej Wroblewski](#))

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Computers that exploit the weird rules of [quantum mechanics](#) may soon crack problems that are unsolvable using existing technology. Today's machines are still far from achieving that, but the field of [quantum computing](#) has made dramatic progress since its inception. Quantum computing has gone from an academic curiosity to a multi-billion-dollar industry in less than half a century and shows no signs of stopping. Here are 12 of the most important milestones on that journey.

1980: THE QUANTUM COMPUTER IS BORN

By the 1970s, scientists had begun thinking about potential crossovers between the new fields of quantum mechanics and information theory. But it was American physicist [Paul Benioff](#) who crystallized many of these ideas when he published the first-ever [description](#) of a quantum computer. He proposed a quantum version of a "Turing machine" — a theoretical model of a computer, devised by renowned British computer

scientist Alan Turing, that is capable of implementing any algorithm. By showing that such a device could be described using the equations of quantum mechanics, Benioff laid the foundations for the new field of quantum computing.

1981: RICHARD FEYNMAN POPULARIZES QUANTUM COMPUTING

Both Benioff and legendary physicist [Richard Feynman](#) gave talks on quantum computing at the first [Physics of Computation Conference](#) in 1981. Feynman's [keynote speech](#) was on the topic of using computers to simulate physics. He pointed out that because the physical world is quantum in nature, simulating it exactly requires computers that similarly operate based on the rules of quantum mechanics. He introduced the concept of a "quantum simulator," which cannot implement any program like a Turing machine, but can be used to simulate quantum mechanical phenomena. The talk is often credited for kick-starting interest in quantum computing as a discipline.

1985: THE "UNIVERSAL QUANTUM COMPUTER"

One of the foundational concepts in computer science is the idea of the universal Turing machine. Introduced by its namesake in 1936, this is a particular kind of Turing machine that can simulate the behavior of any other Turing machine, allowing it to solve any problem that is computable. However, [David Deutsch](#), a professor in the quantum theory of computation, pointed out in [a 1985 paper](#) that because the universal computer described by Turing relied on classical physics, it would be unable to simulate a quantum computer. He reformulated Turing's work using quantum mechanics to devise a "universal quantum computer," which is capable of simulating any physical process.

1994: FIRST KILLER USE CASE FOR QUANTUM COMPUTERS

Despite the theoretical promise of quantum computers, researchers had yet to find clear practical applications for the technology. American mathematician [Peter Shor](#) became the first to do so when he introduced a quantum algorithm that could efficiently factorize large numbers. Factorization is the process of finding the smallest set of numbers that can be combined to create a larger one. This process becomes increasingly difficult for larger numbers and is the basis for many [leading encryption schemes](#). Shor's algorithm can solve these problems exponentially faster than classical computers, though, raising fears that quantum computers could be used to crack modern encryption and spurring the development of post-quantum cryptography.

1996: QUANTUM COMPUTING TAKES ON SEARCH

It didn't take long for another promising application to appear. Bell Labs computer scientist [Lov Grover proposed](#) a quantum algorithm for unstructured search, which refers to looking for information in databases with no obvious system of organization. This is like looking for the proverbial needle in a haystack and is a common problem in computer science, but even the best classical search algorithms can be slow when faced with large amounts of data. The Grover algorithm, as it has become known, exploits the quantum phenomenon of superposition to dramatically speed up the search process.

1998: FIRST DEMONSTRATION OF A QUANTUM ALGORITHM

Dreaming up quantum algorithms on a blackboard is one thing, but actually implementing them on hardware had proven much harder. In 1998, a team led by IBM researcher [Isaac Chuang](#) made a breakthrough when they [showed](#) that they could run Grover's algorithm on a computer featuring two qubits — the quantum equivalent of bits. Just three years later Chuang also led the [first implementation](#) of Shor's algorithm on quantum hardware, factoring the number 15 using a seven-qubit processor.

1999: THE BIRTH OF THE SUPERCONDUCTING QUANTUM COMPUTER

The fundamental building blocks of a quantum computer, [known as qubits](#), can be implemented on a wide range of different physical systems. But in 1999, physicists at Japanese technology company NEC hit upon an approach that would go on to become the most popular approach to quantum computing today. In a [paper in Nature](#), they showed that they could use superconducting circuits to create qubits, and that they could control these qubits electronically. Superconducting qubits are now used by many of the leading quantum computing companies, including Google and IBM.

2011: FIRST COMMERCIAL QUANTUM COMPUTER RELEASED

Despite considerable progress, quantum computing was still primarily an academic discipline. The [launch](#) of the first commercially available quantum computer by Canadian company D-Wave in May 2011 heralded the start of the quantum computing industry. The start-up's D-Wave One featured 128 superconducting qubits and cost roughly \$10 million. However, the device wasn't a universal quantum computer. It used an approach known as quantum annealing to solve a specific kind of optimization problem, and there was little evidence it provided any speed boost compared to classical approaches.

2016: IBM MAKES QUANTUM COMPUTER AVAILABLE OVER THE CLOUD

While several large technology companies were developing universal quantum computers in-house, most academics and aspiring quantum developers had no way to experiment with the technology. In May 2016, IBM made its five-qubit processor [available over the cloud](#) for the first time, allowing people from outside the company to run quantum computing jobs on its hardware. Within two weeks more than 17,000 people had registered for the company's IBM Quantum Experience service, giving many their first hands-on experience with a quantum computer.

2019: GOOGLE CLAIMS "QUANTUM SUPREMACY"

Despite theoretical promises of massive "speedup," nobody had yet demonstrated that a quantum processor could solve a problem faster than a classical computer. But in September 2019, [news emerged](#) that Google had used 53 qubits to perform a calculation in 200 seconds that it claimed would take a [supercomputer](#) roughly 10,000 years to complete. The problem in question had no practical use: Google's processor simply performed random operations and then researchers calculated how long it would take to simulate this on a classical computer. But the result was hailed as the first example of "quantum supremacy," now more commonly referred to as "quantum advantage."

2022: A CLASSICAL ALGORITHM PUNCTURES SUPREMACY CLAIM

Google's claim of quantum supremacy was met with skepticism from some corners, in particular from arch-rival IBM, which claimed the speedup was overstated. A group from

the Chinese Academy of Sciences and other institutions eventually showed that this was the case, by devising a [classical algorithm](#) that could simulate Google's quantum operations in just 15 hours on 512 GPU chips. They claimed that with access to one of the world's largest supercomputers, they could have done it in seconds. The news was a reminder that classical computing still has plenty of room for improvement, so quantum advantage is likely to remain a moving target.

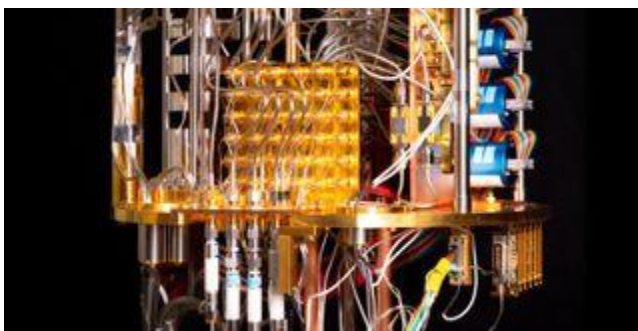
2023: QUERA SMASHES RECORD FOR MOST LOGICAL QUBITS

One of the biggest barriers for today's quantum computers is that the underlying hardware is highly error-prone. Due to the quirks of quantum mechanics, fixing those errors is tricky and it has long been known that it will take many physical qubits to create so-called "logical qubits" that are immune from errors and able to carry out operations reliably. Last December, Harvard researchers working with start-up QuEra smashed records by generating 48 logical qubits at once – 10 times more than anyone had previously achieved. The team was able to run algorithms on these logical qubits, marking a major milestone [on the road to fault-tolerant quantum computing](#).

Quantum computing breakthrough could happen with just hundreds, not millions, of qubits using new error-correction system

published April 29, 2024

Scientists have designed a physical qubit that behaves as an error-correcting "logical qubit," and now they think they can scale it up to make a useful quantum computer using a few hundred.



(Image credit: Nord Quantique)

Quantum computers that are more powerful than the [fastest supercomputers](#) could be closer than experts have predicted, researchers from startup Nord Quantique argue.

That's because the company has built an individual error-correcting physical qubit that could dramatically cut the number of qubits needed to achieve quantum advantage (which is where quantum computers are genuinely useful).

Eventually, this could lead to a machine that achieves quantum supremacy — where a quantum computer is more powerful than classical computers.

Unlike classical bits that encode data as 1 or 0, qubits rely on the laws of [quantum mechanics](#) to achieve "coherence" and encode data as a superposition of 1 or 0 — meaning data is encoded in both states simultaneously.

In [quantum computers](#), multiple qubits can be stitched together through [quantum entanglement](#) — where qubits can share the same information no matter how far they are separated over time or space — to process calculations in parallel, while classical computers can only process calculations in sequence.

But qubits are "noisy," meaning they are highly prone to interference from their environment, such as changes in temperature, which leads to high error rates. For that reason, they often need to be cooled to near [absolute zero](#), but even then they can still fall into "decoherence" midway through calculations and fail due to external factors.

Related: [How could this new type of room-temperature qubit usher in the next phase of quantum computing?](#)

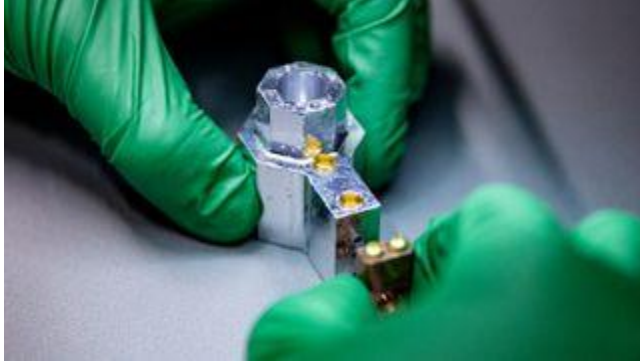
This high error rate means a quantum computer would need to have millions of qubits to achieve quantum supremacy. But today's most powerful quantum computers contain [just 1,000 qubits](#).

This is why research is heavily focused on reducing qubit error rate. One way to reduce errors is by building a "logical qubit," in which several qubits are entangled to behave as one effective, error-free qubit during calculations. This relies on redundancy — a concept in computer science in which the same data is stored in multiple places.

A physical qubit that behaves like a logical qubit

Scientists at Nord Quantique have taken a different approach, instead designing an individual physical qubit, then applying "bosonic codes" during operation to reduce errors at the individual qubit level. They outlined their findings in a study published April 12 in the journal [Physical Review Letters](#). Bosonic codes are error-correcting codes designed specifically for systems that use bosonic modes — such as [photons](#). They exploit bosons' quantum properties to protect information against errors.

Nord Quantique's scientists built one "bosonic qubit," which is around the size of a walnut, from up to 10 microwave photons, or light particles, that resonate in a highly pure superconducting aluminum cavity — which is cooled to near absolute zero.



Nord Quantique's scientists built one "bosonic qubit," which is around the size of a walnut. (Image credit: Nord Quantique)

The bosonic codes were then applied while calculations were underway to correct two types of quantum errors — "bit-flips," or when 0s and 1s are read as each other; and "phase-flips," when the probability of a qubit being either positive or negative is flipped.

Their bosonic codes extended the coherence time of individual qubits by 14%, which the scientists said is the best result to date. Simulations also showed that error correction is not only viable but likely to be stronger when adding additional qubits to the existing single qubit, scientists wrote in their paper.

Using just hundreds of these qubits in a quantum computer could lead to quantum advantage — rather than the millions of qubits scientists have previously thought we would need, study co-author and Nord Quantique's chief technology officer, [Julien Camirand Lemyre](#), told Live Science. The increased qubit lifetime, thanks to the design, coupled with claimed operational clock speeds of up to 1,000 times more than comparable machines, means vastly more calculations can be performed in this short window. It means the "overhead" of redundant qubits is not required versus a machine that uses no error correction or even one with logical qubits.

The race to build a fault-free quantum computer

Other companies, such as [Quantinuum](#) and [QuEra](#), are using different approaches to reduce the error rate, but most rely on logical qubits. Lemyre argued his company's approach is better than this "brute force" method.

"Nord Quantique's approach to building qubits involves building the redundancy necessary for error correction directly into the hardware that makes up each physical qubit. So, in a sense we are making physical qubits into logical qubits through a combination of our unique architecture and use of what we call bosonic codes," Lemyre said.

Still, obstacles to quantum supremacy remain. Lemyre noted that larger quantum computers will need "a handful of physical qubits" to correct the few errors the bosonic codes miss.

The company's next step is to finish building a system, expected by Fall of this year, with multiple error-correcting physical qubits. If everything goes to plan, Nord Quantique is

hoping to release a quantum computer with about 100 of these qubits by 2028, Lemyre said.

Future quantum computers will be no match for 'space encryption' that uses light to beam data around — with the 1st satellite launching in 2025

published March 27, 2024

Quantum computers will break encryption one day. But converting data into light particles and beaming them around using thousands of satellites might be one way around this problem.



Fearing that quantum computers will render encryption obsolete someday, scientists are proposing new technologies to protect sensitive communications. (Image credit: NanoStockk/Getty Images)

By converting data into light particles and beaming them around the world using satellites, we could prevent encrypted messages from being intercepted by a superpowerful quantum computer, scientists claim.

Currently, messaging technology relies on mathematical, or [cryptographic](#), methods of protection, including end-to-end encryption. This technology is used in WhatsApp — as well as by corporations, the government and the military — to protect sensitive data from being intercepted.

Encryption works by scrambling data or text into what appears to be nonsense, using an algorithm and a key that only the sender and recipient can use to unlock the data. These algorithms can, in theory, be cracked. But they are designed to be so complex that even the fastest supercomputers would take millions of years to translate the data into something readable.

[Quantum computers](#) change the equation. Although the field is young, scientists predict that such machines will be powerful enough to easily break encryption algorithms

someday. This is because they can process exponentially greater calculations in parallel (depending on how many qubits they use), whereas classical computers can process calculations only in sequence.

Fearing that quantum computers will render encryption obsolete someday, scientists are proposing new technologies to protect sensitive communications. One field, known as "quantum cryptography," involves building systems that can protect data from encryption-beating quantum computers.

Unlike classical cryptography, which relies on algorithms to scramble data and keep it safe, quantum cryptography would be secure thanks to the weird quirks of [quantum mechanics](#), according to [IBM](#).

For example, in a paper published Jan. 21 in the journal Advanced Quantum Technologies, scientists describe a mission called "Quick3," which uses [photons](#) — particles of light — to transmit data through a massive satellite network.

"Security will be based on the information being encoded into individual light particles and then transmitted," [Tobias Vogl](#), professor of quantum communication systems engineering at TUM and co-author of the paper, said in a [statement](#). "The laws of physics do not permit this information to be extracted or copied."

That's because the very act of measuring a quantum system changes its state.

"When the information is intercepted, the light particles change their characteristics," he added. "Because we can measure these state changes, any attempt to intercept the transmitted data will be recognized immediately, regardless of future advances in technology."

The challenge with traditional Earth-based quantum cryptography, however, lies in transmitting data over long distances, with a maximum range of just a few hundred miles, the TUM scientists said in the statement. This is because light tends to scatter as it travels, and there's no easy way to copy or amplify these light signals through fiber optic cables.

Scientists have also experimented with storing encryption keys in entangled particles — meaning the data is intrinsically shared between two particles over space and time no matter how far apart. A [project in 2020](#), for example, demonstrated "quantum key distribution" (QKD) between two ground stations 700 miles apart (1,120 km).

When it comes to transmitting photons, however, at altitudes higher than 6 miles (10 kilometers), the atmosphere is so thin that light is not scattered or absorbed, so signals can be extended over longer distances.

The Quick3 system would involve the entire system for transmitting data in this way, including the components needed to build the satellites. The team has already tested each component on Earth. The next step will be to test the system in space, with a satellite launch scheduled for 2025.

They will probably need hundreds, or perhaps even thousands, of satellites for a fully working quantum communications system, the team said.

World's 1st fault-tolerant quantum computer launching this year ahead of a 10,000-qubit machine in 2026

published February 1, 2024

QuEra has dramatically reduced the error rate in qubits — with its first commercially available machine using this technology launching with 256 physical qubits and 10 logical qubits.



The new machine, which has 256 physical and 10 logical qubits, is expected to launch in late 2024. (Image credit: bpawesome/Getty Images)

The world's first commercial fault-tolerant quantum computer with "logical qubits" may be running before the year's end.

Logical qubits — physical quantum bits, or qubits, connected through [quantum entanglement](#) — reduce errors in quantum computers by storing the same data in different places. This diversifies the points of failure when running calculations.

The new machine, which has 256 physical and 10 logical qubits, will launch in late 2024, representatives from QuEra, the startup that is building it, said in a [statement](#).

The announcement follows a new study, published Dec. 6, 2023 in the journal [Nature](#), in which researchers from Harvard, QuEra and several other institutions demonstrated a functioning quantum computer that contained 48 logical qubits — the largest number of logical qubits tested to date.

"It is the first machine with quantum error correction," study co-author [Harry Zhou](#), a physicist at QuEra and Harvard University, told Live Science in an email.

While this computer doesn't have enough power to be useful on its own, it provides a platform on which software programmers can start testing code for future quantum computers, Zhou said.



Zoom-in view of the glass cell of Harvard experiment, where atoms are trapped and manipulated to perform complex logical algorithms. (Image credit: IQuEra)

Why quantum computing needs error-correction

While conventional computers store information in bits with a value of either 0 or 1, quantum computers use qubits — which are a superposition between 0 and 1, thanks to the laws of [quantum mechanics](#).

Qubits can also be stitched together using quantum entanglement to exist in multiple states simultaneously. This enables them to perform many calculations much faster than classical computers — assuming you can build a quantum computer with enough of them. But qubits can easily be disturbed, making them notoriously error-prone. Roughly 1 in 1,000 fail, [versus 1 in 1 billion billion bits in conventional computers](#).

Quantum computers could outpace the best supercomputers if they incorporate millions of qubits, but the largest quantum computer built so far only has around 1,000 qubits, and qubits' high failure rate limits potential scale-up. Error correction could counteract qubits' tendency to fail, and building logical qubits is one way of doing it.

Logical qubits: turning down the quantum noise

The new error-correction system relies on data redundancy, where the same piece of data is stored in multiple places, Zhou said. Logical qubits perform the same calculations across

several physical qubits — vastly reducing error rates if one or more physical qubits fail, because the data is available elsewhere so calculations can continue.

To make the logical qubit, researchers applied error-correcting computer code to regular qubits. They then set up logical gates, or circuits, between the qubits to entangle them. The quantum computer then calculates the 'syndrome' — a measure of whether it's likely an error has occurred or not. Using this information, the quantum computer corrects the errors and proceeds to the next step.

The new qubits represent a significant advance over past efforts. In 2023, the Google Quantum AI Lab [demonstrated a 2.9% error rate](#) using three logical qubits; QuEra's error rate is 0.5% with 48 logical qubits. The world leader is the University of Oxford, [which has achieved error rates of less than 0.01%](#) — but only between two-qubit gates.

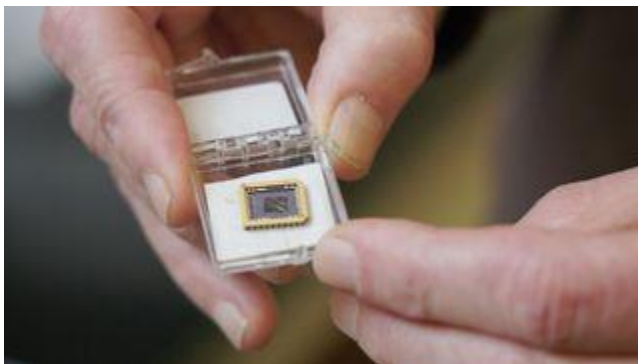
Last year, IBM also demonstrated error-correction technology in its [127-qubit Heron chip](#) which reduced error rates fivefold compared with its other chips. But its first commercial fault-tolerant machine isn't expected until 2029.

QuEra plans to launch several quantum computers in the coming years, starting with a 30-logical-qubit, 3,000 physical qubit machine coming out in 2025. Its monster, a machine with more than 10,000 physical qubits and 100 logical qubits, is scheduled for 2026. "At 100 logical qubits, the [2026] machine can perform correct calculations that exceed the capability of today's supercomputers," Zhou said.

World's 1st graphene semiconductor could power future quantum computers

published January 8, 2024

Scientists overcame a limitation in graphene to harness the material as a working semiconductor at terahertz frequencies with 10 times the mobility of silicon.



Like light, electrons in graphene have quantum mechanical wave-like properties that can be accessed in devices, making such a semiconductor a good choice for use in future quantum computers. (Image credit: Christopher McKenney/Georgia Tech)

Scientists have created the world's first working graphene-based semiconductor, which could pave the way for chips that power much faster PCs and quantum computers in the future.

The new semiconducting material, made from epitaxial graphene (a particular crystal structure of carbon chemically bonded to silicon carbide), allows for more mobility than [silicon](#), meaning electrons move with less resistance. Transistors made in this way can operate at terahertz frequencies — 10 times faster than the silicon-based transistors used in chips used today — the researchers wrote in a study published Jan. 3 in the journal [Nature](#).

Semiconductors have properties of both conductors and insulators. At the right temperature range, electrons move through the semiconductor material — but only if a certain amount of energy is applied.

Almost every chip uses a semiconductor made from silicon, but the material is reaching its limits, lead researcher [Walt de Heer](#), a professor at the Georgia Institute of Technology, told Live Science in an email. These limits include the maximum speed at which transistors can "switch" between their on-off positions, the heat they generate through resistance and the smallest size people can make them.

This means the rapid advancements we've seen throughout the [history of computing](#) are beginning to slow.

[Graphene](#), meanwhile, is made from a single layer of carbon atoms tightly bound in a hexagonal lattice, and is a better conductor than silicon, meaning electrons move with less resistance through the material.

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Despite its favorable properties, graphene has never been harnessed in electronics because of the lack of a "band gap" — a minimum amount of energy needed to move electrons when an electric field is applied to it. Band gaps are what enable transistors to switch on and off.

To function as a working transistor, the graphene must be treated in some way, but in the past, this has damaged its properties, de Heer said.

But the researchers worked around this challenge by fusing graphene onto silicon carbide using special furnaces and a special heating and cooling process. By putting atoms on the graphene that "donate" electrons to the system, which is known as "doping", they created a functional graphene semiconductor with a band gap.

Not only is this the first graphene-based semiconductor to work, but it can also be integrated into existing manufacturing processes. The transition from making silicon wafers to the silicon carbide wafers used in epitaxial graphene is "quite feasible," de Heer said.

Graphene-based semiconductors also have a potential future use in quantum computing, the researchers wrote in the study.

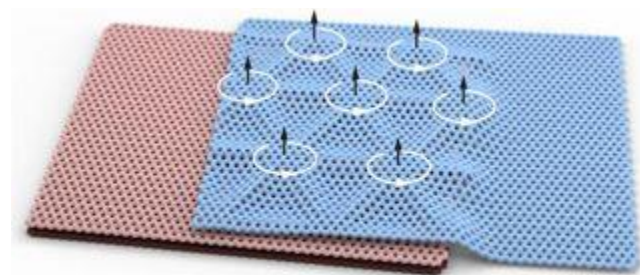
"Like light, electrons in graphene have quantum mechanical wave-like properties that can be accessed in devices, particularly at very low temperatures," de Heer said.

This is an area the scientists hope to explore in subsequent research, but de Heer said it remains to be seen whether graphene-based semiconductors can work better than the current [superconducting](#) technology, which is used in the most advanced quantum computers.

Rare magnetism found in the world's strongest material

published October 14, 2020

Strange things happen when you stack and twist graphene.



A stacked and twisted set of graphene sheets leads to a rare form of magnetism, in which electrons across the stacks swirl in unison. (Image credit: Columbia University)

Graphene, one of the world's strongest materials, isn't normally magnetic. But when stacked and twisted, graphene develops a rare form of [magnetism](#), new research finds. The magnetic field isn't created by the usual spin of electrons within the individual graphene layers, but instead arises from the collective swirling of electrons in all of the three-layers of the stacked graphene structure, researchers reported Oct. 12 in the journal [Nature Physics](#).

Graphene is a material made of a single layer (or monolayer) of [carbon atoms](#) arranged in a honeycomb pattern. It's incredibly light and strong (though it is vulnerable to cracking). It also conducts electricity, making it exciting for use in electronics and sensors.

"We wondered what would happen if we combined graphene monolayers and bilayers into a twisted three-layer system," Cory Dean, a physicist at Columbia University in New York and one of the senior authors on the new paper, [said in a statement](#). "We found that varying the number of graphene layers endows these composite materials with some exciting new properties that had not been seen before."

Dean and his colleagues stacked two layers of graphene and then added a single layer on top, rotating the stack by 1 degree. They then studied this graphene sandwich in a variety of circumstances, including temperatures just above absolute zero (the point at which all molecular motion stops). At these low temperatures, they found that the graphene stopped conducting electricity and became an insulator instead.

They also found that they could control the properties of the twisty stack of graphene by applying an [electric field](#). When the electric field was oriented in one direction, the system acted like a twisted double layer of graphene. When they reversed the field, the stack took on the properties of a twisted four-layer graphene structure.

Perhaps strangest of all was the rare magnetism that appeared in the three-layer structure. A study published by another group in the journal [Advanced Materials](#) found that graphene bonded with [boron](#) nitride can give rise to a strange magnetic field; that field arose from the molecular bonds of the carbon in graphene and the boron in boron nitride. The new research reveals that this same type of magnetism can occur in pure graphene alone, simply because of interactions between carbon molecules.

"Pure carbon is not magnetic," study co-author Matthew Yankowitz, a physicist at the University of Washington in Seattle, said in the statement. "Remarkably, we can engineer this property by arranging our three graphene sheets at just the right twist angles."

The structure also contains regions where the properties are undisturbed by the twisting of the layer. These unique areas in the material could be exploited for data storage or quantum computing applications, study co-author Xiaodong Xu, also at the University of Washington, said in the statement.

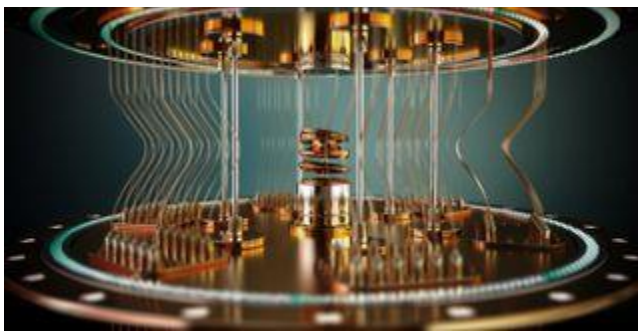
The researchers are now planning to delve deeper into the fundamental properties of the graphene structure. "This is really just the beginning," Yankowitz said.

Originally published on Live Science.

How could this new type of room-temperature qubit usher in the next phase of quantum computing?

published January 29, 2024

The qubit attained quantum coherence for 100 nanoseconds, which an expert described as an "important milestone" in quantum computing research.



The new qubit used a pentacene-based chromophore — a dye molecule that absorbs light and emits color — embedded into a new metal-organic framework (MOF). (Image credit: adventtr/Getty Images)

Scientists have built a qubit, or quantum bit, that can achieve "quantum coherence" at room temperature — something normally only possible at temperatures close to [absolute zero](#). To achieve quantum coherence — a stable state in which the weird laws of [quantum mechanics](#) can be observed — qubits must normally be cooled down to minus 459 degrees Fahrenheit (minus 273 degrees Celsius) or they succumb to disturbances and fail, which is known as decoherence.

To get around this, the new qubit used a pentacene-based chromophore — a dye molecule that absorbs light and emits color — embedded into a new metal-organic framework (MOF). Its properties meant scientists could observe quantum coherence briefly at room temperature, the scientists said in a new paper published Jan. 3 in the journal *Nature*. While classical computers encode data in bits — expressed as either 1 or 0 — quantum computers use qubits, which can be expressed as a superposition of 1 and 0, meaning it can be both states at the same time until physically observed.

Most physical qubits create a superposition between an electron's spin-up and spin-down positions — two binary states that behave as 1 and 0. They are normally a line of metal, or a tiny loop, that behaves as an atom. Google uses aluminum in its qubits, while IBM uses a mix of aluminum and niobium, according to [Scientific American](#).

Multiple qubits that encode information via electron spin can also be joined by [quantum entanglement](#) — when the states of two or more particles are linked — meaning the entangled qubits can exist in many states simultaneously. This is what makes quantum

computers potentially so much more powerful than classical computers if built with enough qubits.

How the new type of qubit works

Electrons in chromophores can be excited via a process called singlet fission, in which they absorb light and change their spin states. In the past, researchers used singlet fission to create superposition in qubits, but they only achieved this below minus 324 F (minus 198 C), the scientists wrote in the paper.

For the new study, the scientists used a chromophore based on pentacene hydrocarbon, in which pentagonal rings of carbon and hydrogen are linked together. To achieve this same quantum state at higher temperatures, the researchers trapped the chromophore molecules in the MOF — a unique crystalline material composed of metal ions and bound by organic molecules.

The MOF almost completely restricted the dye molecule's movement, helping keep any excited electrons in an entangled state. The scientists then excited the electrons in the chromophore via singlet fission by exposing them to microwave pulses. Tiny holes in the crystalline structure, known as nanopores, enabled the electrons to rotate at a tiny and specific angle, the study's lead author [Nobuhiro Yanai](#), an associate professor of chemistry at Kyushu University, said in a [statement](#).

This slight rotation enabled excited electrons to transition from two pairs of electrons in excited "triplet states" — in which electrons from different molecular orbits have parallel spins — into one set of four electrons in the less stable "quintet state," in which the electron spins are antiparallel — meaning they are parallel but are moving in opposite directions. In this quintet state, the laws of quantum mechanics dominate.

Following this process, the researchers observed quantum coherence in these four electrons in a quintet state for over 100 nanoseconds at room temperature (one nanosecond is a billionth of a second).

Pursuing room-temperature quantum computers

It's the first room-temperature quantum coherence of entangled quintet-state electrons, said study co-author [Yasuhiro Kobori](#), a professor of chemistry at Kobe University, in the statement.

In follow-up work, the team hopes to create more stable qubits by adding other "guest" molecules that further restrict the electron motion, or by playing around with the underlying structure of the MOF, Yanai said in the statement.

While the new research is unlikely to lead to room-temperature quantum computing in the foreseeable future, the breakthrough adds to the body of work that's gone into building qubits that can achieve quantum coherence at room temperature. Indeed, producing stable qubits at room temperature has been a hope for a long time, [Vlatko Vedral](#), a professor of quantum information science at the University of Oxford, told Live Science.

Such room-temperature computing would avoid the need for error correction, he said. This is because to work at room temperature, the qubits would by design need to withstand the disruptive forces that render them unstable and prone to decoherence.

"In this paper, long spin coherence times are indeed reported which is a significant advancement," he said. "However, I am not sure how easy it is to scale this up, and — in particular — how easy it is to control the interactions between qubits. It seems to me this will be the bottleneck since isolated qubits with long coherence times are not of much use for quantum computation." In other words, to make a powerful computer, you need many qubits to perform calculations.

Despite casting doubt on the utility of this specific discovery, Vedral hailed it as "an important milestone," adding this body of research is more promising in the long run than developing ways to perform quantum error correction.

Quantum computers could overtake classical ones within 2 years, IBM 'benchmark' experiment shows

published June 15, 2023

A new experiment by IBM computers shows that quantum computers could soon outperform classical digital computers at practical tasks in the next two years.



A quantum computer (not the Eagle supercomputer used in the study). (Image credit: John D/Getty)

Quantum computers could beat classical ones at answering practical questions within two years, a new experiment from IBM computers shows. The demonstration hints that true quantum supremacy, in which quantum computers overtake classical digital ones, could be here surprisingly soon.

"These machines are coming," [Sabrina Maniscalco](#), CEO of Helsinki-based quantum-computing startup Algorithmiq, told [Nature News](#).

In the new study, described Wednesday (June 14) in the journal [Nature](#), scientists used IBM's [quantum computer](#), known as Eagle, to simulate the magnetic properties of a real material faster than a classical computer could. It achieved this feat because it used a special error-mitigating process that compensated for noise, a fundamental weakness of quantum computers.

By contrast, quantum computers employ quantum bits, or qubits, that can take on many states at once. Qubits rely on quantum phenomena such as superposition, in which a particle can exist in multiple states simultaneously, and on [quantum entanglement](#), in which the states of distant particles can be linked so that changing one instantaneously changes the other. In theory, this allows qubits to make calculations much faster, and in parallel, that digital bits would do slowly and in sequence.

But historically, quantum computers have had an Achilles' heel: The quantum states of qubits are incredibly delicate, and even the tiniest [disruption from the outside environment can mess with their states](#) — and thereby the information they carry — forever. That makes quantum computers very error-prone or "noisy."

In the new proof-of-principle experiment, the 127-qubit Eagle supercomputer, which uses qubits built on superconducting circuits, calculated the complete magnetic state of a two-dimensional solid. The researchers then carefully measured the noise produced by each of the qubits. It turned out that certain factors, such as defects in the supercomputing material, could reliably predict the noise generated in each qubit. The team then used these predictions to model what the results would have looked like without that noise, [Nature News](#) reported.

Claims of quantum supremacy have surfaced before: In 2019, [Google scientists claimed that the company's quantum computer, known as Sycamore, had solved a problem in 200 seconds](#) that an ordinary computer would take 10,000 years to crack. But the problem it solved — essentially spitting out a huge list of random numbers and then checking their accuracy, had no practical use.

By contrast, the new IBM demonstration applies to a real — albeit highly simplified — physical problem.

"It makes you optimistic that this will work in other systems and more complicated algorithms," [John Martinis](#), a physicist at the University of California, Santa Barbara, who achieved the 2019 Google result, told [Nature News](#).

You can read more about the quantum computing milestone at [Nature News](#).

Otherworldly 'time crystal' made inside Google quantum computer could change physics forever

published September 14, 2021

The crystal is able to forever cycle between states without losing energy.



The time crystal was created inside Google's Sycamore chip, which is kept cool inside their quantum cryostat. (Image credit: Eric Lucero/Google, Inc.)

Researchers working in partnership with Google may have just used the tech giant's quantum computer to create a completely new [phase of matter](#) — a time crystal. With the ability to forever cycle between two states without ever losing energy, time crystals dodge one of the most important laws of physics — the [second law of thermodynamics](#), which states that the disorder, or entropy, of an isolated system must always increase. These bizarre time crystals remain stable, resisting any dissolution into randomness, despite existing in a constant state of flux.

According to a research article posted July 28 to the preprint database [arXiv](#), scientists were able to create the time crystal for roughly 100 seconds using qubits (quantum computing's version of the traditional computer bit) inside the core of Google's Sycamore quantum processor.

The existence of this weird new matter phase, and the entirely new realm of physical behaviors it reveals, is incredibly exciting to physicists, especially as time crystals were only first predicted to exist just nine years ago.

"This was a big surprise," Curt von Keyserlingk, a physicist at the University of Birmingham in the U.K. who was not involved in the study, told Live Science. "If you asked someone 30, 20 or maybe even 10 years ago, they would not have expected this."

Time crystals are fascinating objects to physicists because they essentially sidestep the second law of thermodynamics, one of the most ironclad laws in physics. It states that entropy (a rough analog for the amount of disorder in a system) always increases. If you want to make something more ordered, you need to put more energy into it.

This tendency for disorder to grow explains a lot of things, such as why it's easier to stir ingredients into a mixture than it is to separate them out again, or why headphone cords

get so tangled in pants' pockets. It also sets the arrow of time, with the past universe always more ordered than the present; watching a video in reverse, for instance, is likely to look strange to you primarily because you're witnessing the counterintuitive reversal of this entropic flow.



[The second law of thermodynamics says that all systems evolve toward a state of more disorder, where energy is shared out evenly across the system. \(Image credit: Universal History Archive/Universal Images Group via Getty Images\)](#)

Time crystals don't follow this rule. Instead of slowly approaching thermal equilibrium — "thermalizing" so that their energy or temperature is equally distributed throughout their surroundings, they get stuck between two energy states above that equilibrium state, cycling back and forth between them indefinitely.

To explain how deeply unusual this behavior is, von Keyserlingk said to picture a sealed box filled with coins before being shaken a million times. As the coins ricochet from, and bounce around, each other, they "become more and more chaotic, exploring all of the sorts of configurations that they can explore" until the shaking stops, and the box is opened to reveal the coins in a random configuration, with roughly half of the coins facing up and half facing down. We can expect to see this random, half-up, half-down endpoint regardless of the way we first arranged the coins in the box.

Inside the "box" of Google's Sycamore, we can view the quantum processor's qubits much like we would our coins. In the same way that the coins can be either heads or tails, qubits can be either a 1 or a 0 — the two possible positions in a two-state system — or a weird mix of the probabilities of both states called a superposition. What's weird about time crystals, von Keyserlingk says, is that no amount of shaking, or zapping from one state to another, can move the time crystal's qubits into the lowest energy state, which is a random configuration; they can only flip it from its starting state to its second state, then back again.

"It just sort of flip-flops," von Keyserlingk said. "It doesn't end up looking random, it just gets jammed stuck. It's like it remembers what it looked like initially, and it repeats that pattern over time."

In this sense, a time crystal is like a pendulum that never stops swinging.

"Even if you totally physically isolate a pendulum from the universe, so there's no friction and no air resistance, it will eventually stop. And that's because of the second law of thermodynamics," Achilleas Lazarides, a physicist at the University of Loughborough in the U.K. who was among the scientists to first discover the theoretical possibility of the new phase in 2015, told Live Science. "Energy starts out concentrated in the pendulum's center of mass, but there's all of these internal degrees of freedom — like the ways the [atoms](#) can vibrate inside the rod — that it will eventually be transferred into."

In fact, there's no way for a large-scale object to behave like a time crystal without sounding absurd, because the only rules that enable time crystals to exist are the spooky and surreal rules that govern the world of the very small — [quantum mechanics](#).

In the quantum world, objects behave both like point particles and little waves at the same time, with the magnitude of these waves in any given region of space representing the probability of finding a particle at that location. But randomness (such as random defects in a crystal's structure or a programmed randomness in the interaction strengths between qubits) can cause a particle's probability wave to cancel itself out everywhere apart from one very small region. Rooted in place, unable to move, change states or thermalize with its surroundings, the particle becomes localized.

The researchers used this localization process as the foundation of their experiment. Using 20 strips of superconducting [aluminum](#) for their qubits, the scientists programmed each one into one of two possible states. Then, by blasting a microwave beam over the strips, they were able to drive their qubits to flip states; the researchers repeated the experiment for tens of thousands of runs and stopped at different points to record the states their qubits were in. What they found was that their collection of qubits was flipping back and forth between only two configurations, and the qubits weren't absorbing heat from the microwave beam either — they had made a time crystal.

They also saw a key clue that their time crystal was a phase of matter. For something to be considered a phase, it usually has to be very stable in the face of fluctuations. Solids will not melt if the [temperatures](#) around them vary slightly; neither will slight fluctuations cause liquids to evaporate or freeze suddenly. In the same way, if the microwave beam used to flip the qubits between states was adjusted to be close to but slightly off from the exact 180 degrees needed for a perfect flip, the qubits still nonetheless flipped to the other state.

"It's not the case that if you're not exactly at the 180 degrees you will scramble them," Lazarides said. "It [the time crystal] magically will always tip a bit in, even if you're making slight mistakes."

Another hallmark of moving from one phase to another is the breaking of physical symmetries, the idea that the laws of physics are the same for an object at any point in time or space. As a liquid, the molecules in water follow the same physical laws at every point in space and in every direction, but cool water down enough so that it transforms into ice and its molecules will pick regular points along a crystal structure — or lattice — to arrange themselves across. Suddenly, the water molecules have preferred points in space to occupy, and they leave the other points empty — the spatial symmetry of the water has been spontaneously broken.

In much the same way that ice becomes a crystal in space by breaking with spatial symmetry, time crystals become crystals in time by breaking with time symmetry. At first, before their transformation into the time crystal phase, the row of qubits will experience a continuous symmetry between all moments in time. But the periodic cycle of the microwave beam chops the constant conditions experienced by the qubits down into discrete packets (making the symmetry imposed by the beam a discrete time-translation symmetry). Then, by flipping back and forth at twice the period of the wavelength of the beam, the qubits break with the discrete time-translation symmetry imposed by the laser. They are the first objects we know of that are able to do this.

All of this weirdness makes time crystals rich in new physics, and the control that Sycamore provides researchers beyond other experimental setups could make it an ideal platform for further investigation. That's not to say it cannot be improved, however. Like all quantum systems, Google's quantum computer needs to be perfectly isolated from its environment to prevent its qubits from undergoing a process called decoherence, which eventually breaks down the quantum localization effects, destroying the time crystal. The researchers are working on ways to better isolate their processor and mitigate the impact of decoherence, but it's unlikely they will eliminate the effect for good.

Despite this, Google's experiment is likely to remain the best way to study time crystals for the foreseeable future. Though numerous other projects have succeeded in making what convincingly appear to be time crystals in other ways — with diamonds, helium-3 superfluids, quasiparticles called magnons and with [Bose-Einstein condensates](#) — for the most part the crystals produced in these setups dissipate too quickly for detailed study. The theoretical newness of the crystals is in some ways a double-edged sword, as physicists currently struggle to find clear applications for them, although von Keyserlingk has suggested that they could be used as highly accurate sensors. Other proposals include using the crystals for better memory storage or for developing quantum computers with even faster processing power.

But in another sense, the greatest application of time crystals may already be here: They allow scientists to probe the boundaries of quantum mechanics.

"It allows you to not just study what shows up in nature, but to actually design it and look at what quantum mechanics lets you do and doesn't let you do," Lazarides said. "If you don't find something in nature then it doesn't mean it can't exist — we just created one of those things."

Originally published on Live Science.

Fast-Switching Luminescent Nanocrystals Could Make Computing Low-Energy

Nanocrystals have been made that can switch between glowing and darkness fast enough that they could be used in computing. Some of the ingredients used in the initial demonstration may impede widespread applications, but the findings are a significant advance down the long road to lower-energy IT as processing demand skyrockets.

So much solar power was installed last year that some experts expect world consumption of fossil fuels [may have peaked](#). Those who disagree with this assessment point to [rising energy consumption](#), particularly for AI and cryptocurrency mining. Instead of simply watching whether renewables can outrace rapidly rising demand, some researchers hope to find more energy-efficient ways of conducting the calculations on which these two energy hogs depend.

A new entrant in this race is doped nanocrystals, whose states of light and dark can represent ones and zeros for information storage. The nanocrystals belong to a class of materials known as optically bistable. That is, they can be in one of two states in terms of light emissions, reflections or transmissions depending on previous exposure, and either state is maintained for extensive periods unless something changes. Previous examples of optical bistability suffered from serious drawbacks, such as depending on temperature changes that make it hard to prevent interference between neighbors.

"Normally, luminescent materials give off light when they are excited by a laser and remain dark when they are not," Dr Artiom Skripka of Oregon State University said in a [statement](#). "In contrast, we were surprised to find that our nanocrystals live parallel lives. Under certain conditions, they show a peculiar behavior: They can be either bright or dark under exactly the same laser excitation wavelength and power."

Exposure to a laser above a certain power will make one of the crystals light up, and when illumination drops below a weaker threshold they turn off, but there's a large zone in between where the previous state is maintained.

"If the crystals are dark to start with, we need a higher laser power to switch them on and observe emission, but once they emit, we can observe their emission at lower laser powers than we needed to switch them on initially," Skripka continued. "It's like riding a bike – to get it going, you have to push the pedals hard, but once it is in motion, you need less effort to keep it going. And their luminescence can be turned on and off really abruptly, as if by pushing a button."

[Photonics](#), which would replace electrons in computing with photons of light, has been an area of great research for decades. The potential benefits are enormous, starting with the vastly greater speed at which light travels.

However, making it work in practice has proven difficult. These crystals may provide a crucial component.

"Integrating photonic materials with intrinsic optical bistability could mean faster and more efficient data processors, enhancing machine learning algorithms and data analysis," Skripka noted. "It could also mean more-efficient light-based devices of the type used in fields like telecommunications, medical imaging and environmental sensing."

The crystals Skripka and colleagues demonstrated have a matrix with a formula of KPbCl , which may alert some people to one potential problem. Society has finally gotten sick enough of the [consequences of lead](#) to try to replace the metal wherever possible, not by finding new applications. In an operating computer, the crystals shouldn't be a problem, but their presence might make disposal of used machines an issue.

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‘MRAM’ memory breakthrough promises to revolutionize computer data storage

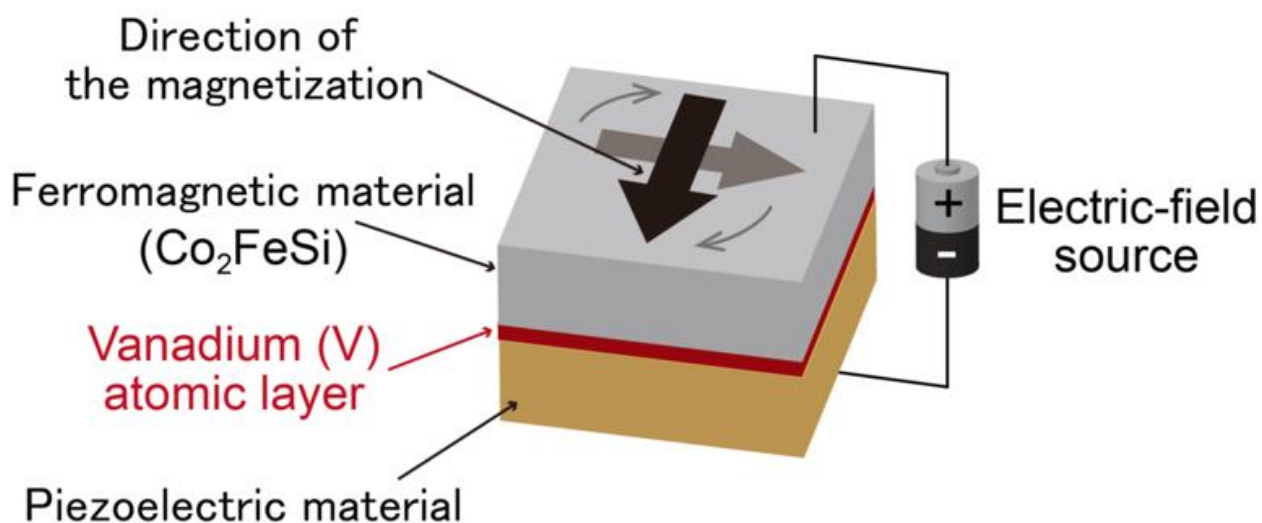
OSAKA, Japan — The future of computer memory might not lie in electrical currents, but in the precise manipulation of magnetic fields. Scientists at Osaka University have demonstrated a novel approach to storing digital information that could dramatically reduce the power consumption of everything from smartphones to data centers, while maintaining the speed and reliability we've come to expect from modern devices.

As memory demands continue to grow in our increasingly digital world, this development marks a significant step toward more efficient and sustainable computing technologies. Like the transition from mechanical to electronic calculators, this breakthrough, detailed in [Advanced Science](#), could herald a new era in how we store and process information.

The advancement centers on a technology called *Magnetoresistive Random-Access Memory* (MRAM), which has emerged as a promising candidate for [next-generation computer memory](#) due to its speed, durability, and compatibility with existing semiconductor manufacturing processes. Traditional computer memory faces a significant challenge: it requires constant power to maintain stored information, similar to how a light bulb needs continuous electricity to stay lit. MRAM, however, uses magnetic states to store information, making it non-volatile – meaning it maintains stored data even when powered off, much like how a refrigerator magnet keeps its magnetic properties without any power source.

“As MRAM devices rely on a non-volatile magnetization state rather than a volatile charge state in capacitors, they are a promising alternative to DRAM in

terms of their low power consumption in the standby state,” says lead author Takamasa Usami in a statement.

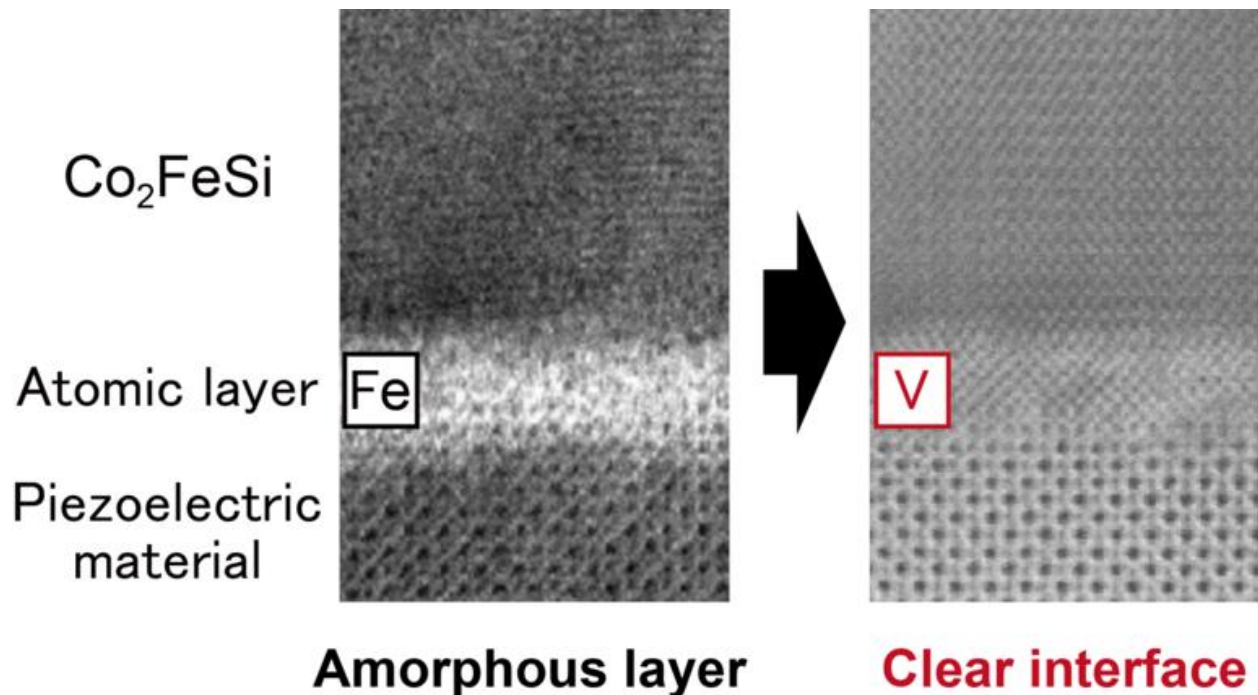


Schematic of the interfacial multiferroic structure. (Credit: T. Usami)

Current MRAM technology faces its own challenges, particularly in how data is written to the memory. Traditional MRAM devices rely on electric currents to write data, but this approach becomes increasingly problematic as devices get smaller, requiring [more power](#) to operate effectively. The process also generates heat through what's known as *Joule heating*, further increasing energy consumption – imagine trying to write with a pencil that gets hotter and heavier as the paper gets smaller.

The research team tackled this challenge by creating a specialized layered structure combining a magnetic material called Co_2FeSi with a piezoelectric crystal known as PMN-PT. When an [electric field](#) is applied to this combination, it creates mechanical strain that can flip the magnetization direction in the Co_2FeSi layer – essentially writing a digital bit of information without using electric current. This approach is more like using a rubber stamp: regardless of size, it requires the same modest amount of pressure to make an impression.

The researchers achieved a particularly strong version of this effect, known as the *magnetoelectric effect*, by carefully engineering the crystal structure of their materials. They discovered that by inserting an ultra-thin layer of vanadium between the magnetic and piezoelectric layers, they could enhance the interaction between them significantly and improve the overall stability of the device.



Atomic image of the ferromagnetic Co₂FeSi layer/atomic layer/piezoelectric layer interface. The structure on the left uses an Fe atomic layer, whereas the V layer, shown on the right, is clear, promoting the crystal orientation of the ferromagnetic Co₂FeSi layer above. (Credit: T. Usami)

Think of the team's innovation as being able to flip a microscopic compass needle using an electric field rather than another magnet. By carefully adjusting the thickness of both the vanadium and Co₂FeSi layers – down to measurements just a few atoms thick – they achieved precise control over this magnetic switching behavior. This fine-tuning capability allowed them to achieve what's known as a "giant" magnetoelectric effect, measuring over 10⁻⁵ seconds per meter – surpassing the performance of similar devices without the vanadium layer.

With the demonstration of this new memory technology, researchers have shown that the [future of computing](#) doesn't necessarily require choosing between performance and efficiency. By harnessing the interaction between electric fields and magnetic materials, they've opened up new possibilities for memory devices that could transform everything from mobile devices to large-scale computing infrastructure.

Paper Summary

Methodology Explained

The researchers created their device by building up layers of materials using a technique called molecular beam epitaxy. They started with a piezoelectric PMN-PT crystal, added an ultra-thin layer of vanadium (ranging from 0.3 to 2 nanometers thick), and topped it with a layer of Co₂FeSi (varying from 10 to 30 nanometers thick). They then used various analytical techniques, including X-ray diffraction and electron microscopy, to study the crystal structure and magnetic properties of their samples.

Results Breakdown

The team found that their device exhibited the strongest magnetoelectric effect when using a 0.3-nanometer-thick vanadium layer and a 30-nanometer-thick Co₂FeSi layer. Under these conditions, they achieved a magnetoelectric coefficient exceeding 10^{-5} seconds per meter, while maintaining distinct magnetic states at zero electric field. The system demonstrated reliable switching behavior and stability at room temperature.

Limitations

While promising, the research was conducted using relatively large crystal substrates. Scaling the technology down to the size needed for commercial memory devices will require additional development. The study also focused primarily on fundamental physical properties rather than practical device implementation.

Discussion and Takeaways

The research demonstrates a viable pathway toward more energy-efficient memory devices. The ability to control magnetization using electric fields rather than currents could significantly reduce power consumption in future computer systems. The team's approach of using vanadium as an interface layer provides a new tool for engineering similar magnetoelectric systems.

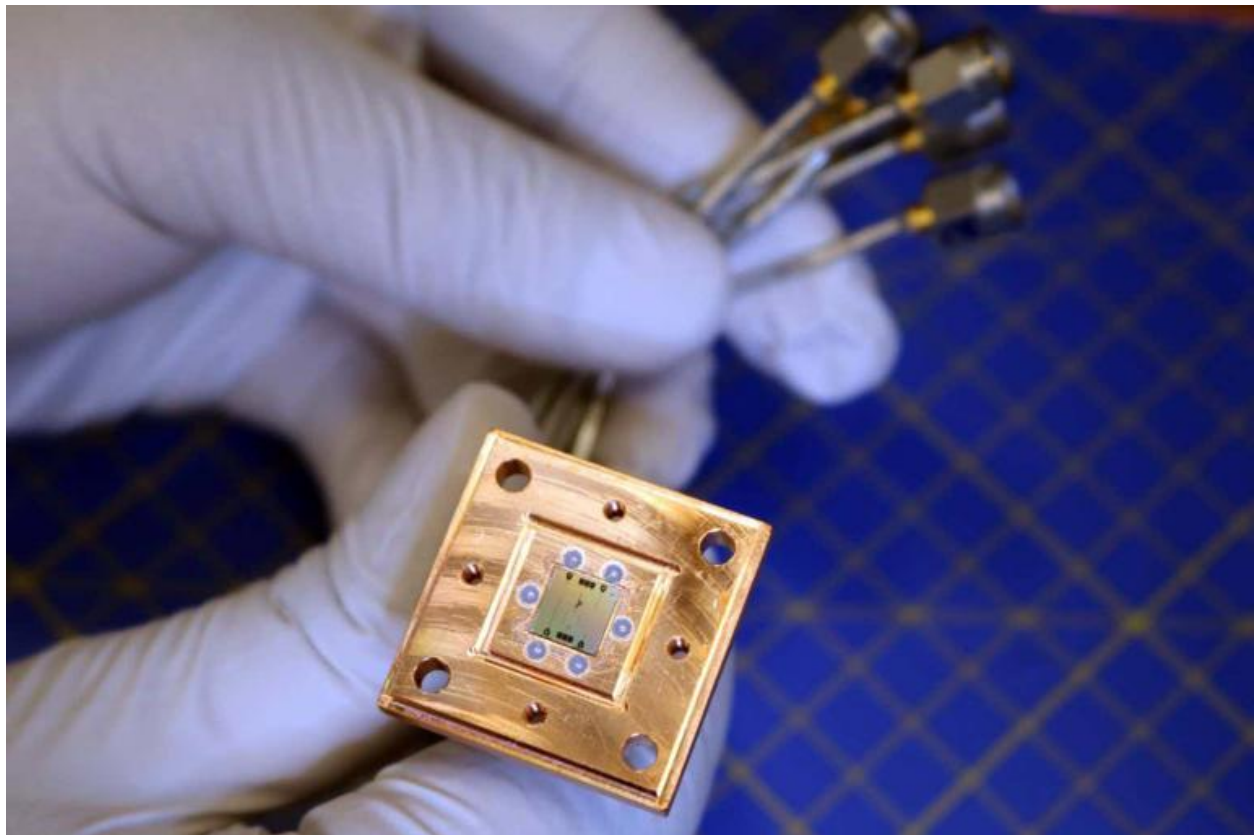
Funding and Disclosures

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Publication Information

The study, titled "Artificial Control of Giant Converse Magnetoelectric Effect in Spintronic Multiferroic Heterostructure," was published in [Advanced Science](#) in 2024. The research was conducted by scientists from Osaka University's Center for Spintronics Research Network and related departments.

Quantum computers get automatic error correction for the first time



Quantum computers could use heat to eliminate errors Chalmers University of Technology, Lovisa Håkansson

A tiny cooling device can automatically reset malfunctioning components of a quantum computer. Its performance suggests that manipulating heat could also enable other autonomous quantum devices.

Quantum computers aren't yet fully practical because they make too many errors. In fact, if qubits – key components of this type of computer – accidentally heat up and become too energetic, they can end up in an erroneous state before the calculation even begins. One way to “reset” the qubits to their correct states is to cool them down.

Quantum trick lets you cool objects down using nothing at all

[Simone Gasparinetti](#) at Chalmers University of Technology in Sweden and his colleagues have delegated this task to an autonomous quantum “refrigerator” for the first time.

The researchers built two qubits and one “qutrit”, which can store more complex information than a qubit, from tiny superconducting circuits. The qutrit and one of the qubits formed a fridge for the second target qubit, which could eventually be used for computation.

The researchers carefully engineered the interactions between the three components to ensure that when the target qubit had too much energy, which caused errors, heat automatically flowed out of it and into the two other elements. This lowered the target qubit’s temperature and reset it. Because this process was autonomous, the qubit-and-qutrit fridge could correct errors without any outside control.

[Aamir Ali](#), also at Chalmers University of Technology, says this approach to resetting the qubit required less new hardware than more conventional methods – and yielded better results. Without any significant quantum computer redesign or introduction of new wires, the qubit’s starting state was correct 99.97 per cent of the time. In contrast, other reset methods typically only manage 99.8 per cent, he says.

This is a powerful example of how thermodynamic machines – which deal with heat, energy and temperature – can be useful in the quantum realm, says [Nicole](#)

[Yunger Halpern](#) at the National Institute of Standards and Technology in Maryland, who worked on the project.

Conventional thermodynamic machines like the heat engine sparked a whole industrial revolution, but so far quantum thermodynamics hasn't been very practical. "I'm interested in making quantum thermodynamics useful. This arguably useful autonomous quantum refrigerator is our first example," says Yunger Halpern.

Is Google's approach to error-free quantum computers already outdated?

"It's nice to see this machine implemented and useful. The fact that it is autonomous, so it does not require any external control, should make it efficient and versatile," says [Nicolas Brunner](#) at the University of Geneva in Switzerland.

[Michał Horodecki](#) at the University of Gdańsk in Poland says that one of the most urgent problems for quantum computers built with superconducting circuits is making sure the machines don't heat up and subsequently make errors. The new experiment opens a path for many similar projects that have been proposed but never tested, such as using qubits to build autonomous quantum engines, he says.

The researchers are already looking into whether they could build on their experiment. For example, they might create an autonomous quantum clock or design a quantum computer with other functions automatically driven by temperature differences.

Journal reference

Nature Physics DOI: <http://dx.doi.org/10.1038/s41567-024-02708-5>

Atomic feline: Engineers use ‘cat with 7 lives’ to prevent quantum computing errors

Researchers at the University of New South Wales (UNSW) have used the famous Schrödinger’s cat thought experiment in the real world to find better ways of correcting errors that accumulate during quantum computations. The approach could solve one of the biggest hurdles in deploying quantum computing for real-world applications.

Quantum computing has the potential to revolutionize the scale and applications of computing devices thanks to its incredible computation speed. Instead of classical bits, quantum computing uses quantum bits or ‘qubits’ that can occupy both on (1) and off (0) states simultaneously.

Known as superposition, this exponentially speeds up calculation speeds since quantum computers can work on multiple possibilities simultaneously. Although extremely beneficial, the approach is also prone to rapidly accumulating errors, which must be corrected. Scientists have been working on different approaches to achieve effective error correction. This has been a major hurdle in the large-scale adoption of quantum computers so far.

Metaphorical Schrödinger’s cat

Devised by Austrian physicist Erwin Schrödinger, [Schrödinger’s Cat](#) is a famous thought experiment in quantum mechanics that tries to explain the conception of superposition. The experiment involves a cat sealed in a box with a mechanism that can potentially kill it.

An observer cannot know if the cat is dead or alive inside the box unless they open it. However, until the box is opened, the cat is dead and alive at the same time or in a state of superposition.

In a real-world experiment, Andrea Morello, a professor of Quantum Engineering at UNSW, used the atom of the heavy element of antimony as a qubit and the metaphorical Schrödinger’s cat.

Using nuclear spins of 'up' and 'down' as the two quantum states of 'on' and 'off' is common in quantum computing. However, when the spin suddenly changes, a quantum system faces a logical error.

Antimony, though, has a large nuclear spin that can take any of the eight directions available to it. So, if '0' is a dead cat and '1' is an alive cat, a change in spin direction will not introduce logical errors immediately.

"Our metaphorical 'cat' has seven lives: it would take seven consecutive errors to turn the '0' into a '1'!" explained Morello in a press release.

Scalable error detection

With technical inputs from researchers at the University of Melbourne, Morello's team embedded the antimony atom inside a silicon quantum chip. This allowed them to encode information in classical binary code while providing large room for error when using logical codes. If an error occurs, the team can spot it and correct it before it accumulates.

"To continue the 'Schrödinger cat' metaphor, it's as if we saw our cat coming home with a big scratch on his face," added Morello in the press release. "He's far from dead, but we know that he got into a fight; we can go and find who caused the fight, before it happens again and our cat gets further injuries."

This opens up a new way of [quantum error correction](#) that can be easily scaled and help deploy quantum computing for real-world applications.

The research findings were published in the journal [Nature Physics](#).

Ultra-thin diamond wafers for electronics made using sticky tape



This thin wafer of diamond is also very flexible Nature, DOI: 10.1038/s41586-024-08218-x

A new way to make ultra-thin diamond wafers using sticky tape could help produce diamond-based electronics, which might one day be a useful alternative to silicon-based designs.

Diamond has unusual electronic properties: it is both a good insulator and allows electrons with certain energies to move with little resistance. This can translate to being able to handle higher energies with greater efficiency than conventional silicon chip designs.

Google says its AI designs chips better than humans – experts disagree

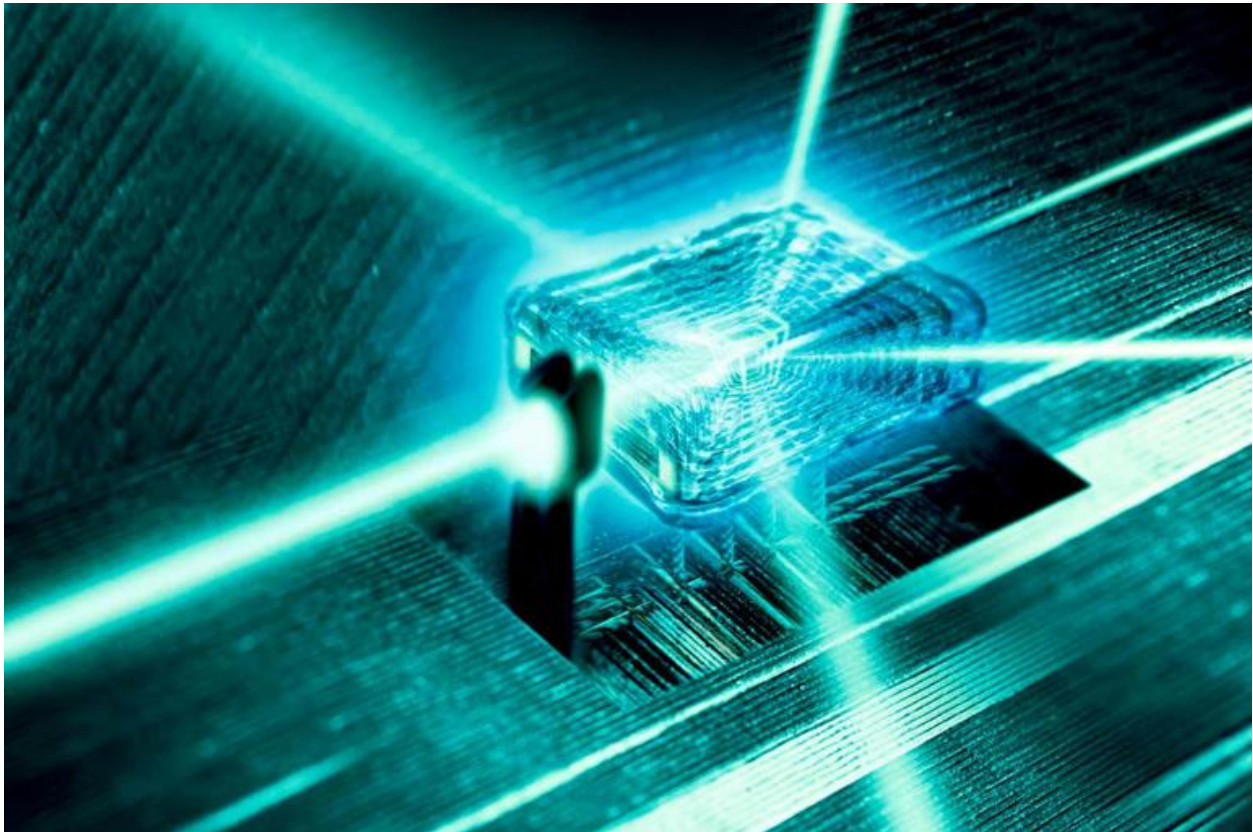
However, producing working diamond chips requires large and very thin wafers, similar to the thin silicon wafers used to build modern computer chips, which have proved tricky to create.

Now, [Zhiqin Chu](#) at the University of Hong Kong and his colleagues have found a way to produce extremely thin and flexible diamond wafers, using sticky tape.

Chu and his colleagues first implanted nano-sized diamonds in a small silicon wafer, then blew methane gas over it at high temperatures to form a continuous, thin diamond sheet. They then created a small crack on one side of the attached diamond sheet, before peeling off the diamond layer using regular sticky tape.

They found that this peeled diamond sheet was both extremely thin, at less than a micrometre, much thinner than a human hair, and smooth enough to allow for the kind of etching techniques used to produce silicon chips.

"It is very reminiscent of the early days of graphene when Scotch tape was used to produce the first monolayer of graphene from graphite. I just never would have imagined the concept being applied to diamond," says [Julie Macpherson](#) at the University of Warwick, UK.



Ultra-thin diamond wafers for electronics made using sticky tape

Diamond could be the super semiconductor the US power grid needs

The hidden semiconductor abilities of diamonds could help power grids and electric vehicles manage far greater amounts of electricity more efficiently

"This new edge-exposed exfoliation method will be an enabler for a multitude of device designs and experimental approaches," says [Mete Atatüre](#) at the University of Cambridge. One area it could be particularly useful for is offering greater control in quantum devices that use diamonds as sensors, he says.

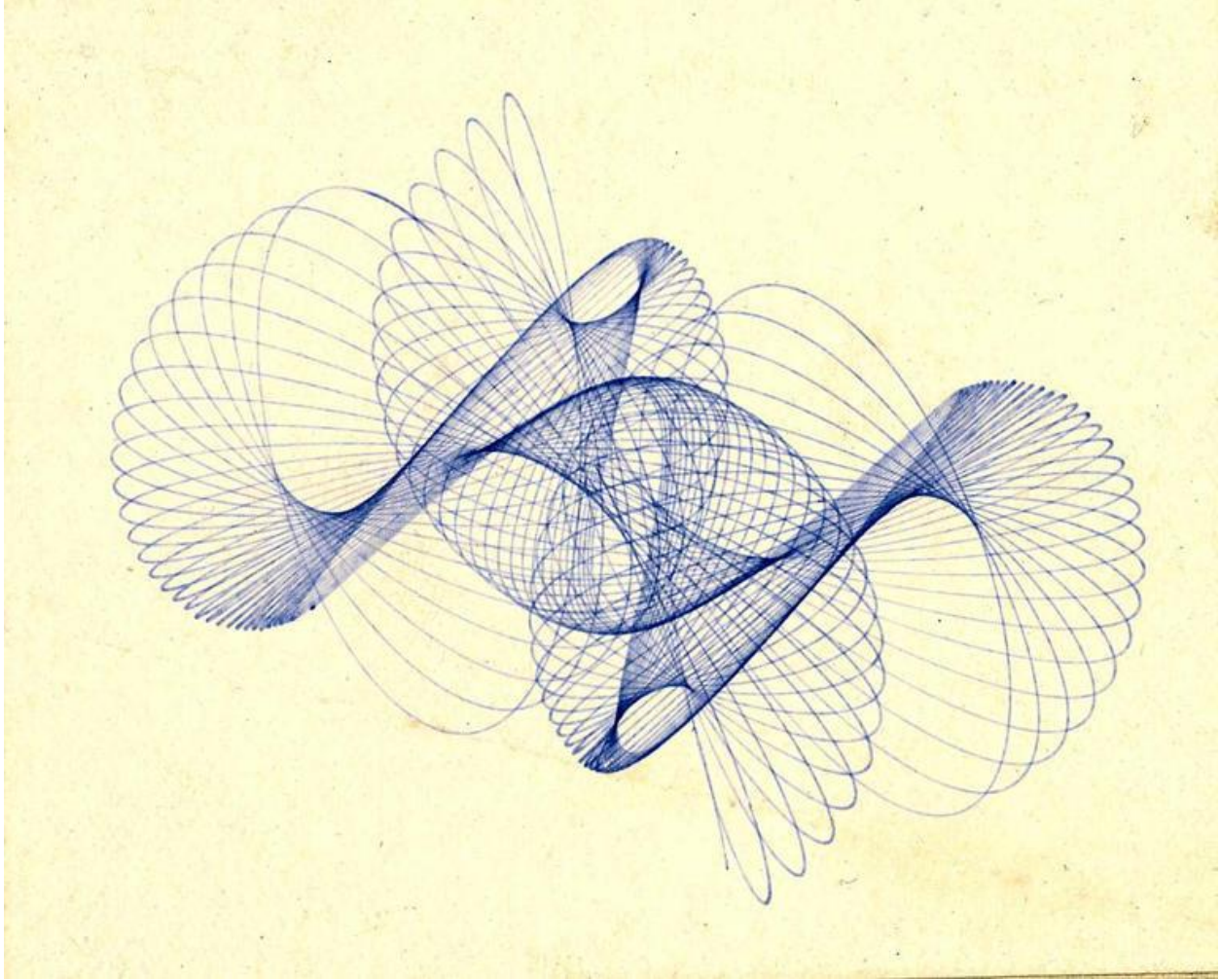
The diamond membranes Chu and his colleagues can produce are about 5 centimetres across, which shows that the method works as a proof of principle, says [Andrea Ferrari](#) at the University of Cambridge, but it is still smaller than the larger 20-30 centimetres that is standard to many wafer processes, and it isn't clear whether the new method can be scaled up, he says.

The wafers produced also appear to be polycrystalline, which are less smooth and regular than monocrystalline diamond, and this could limit its use for some applications, says Macpherson.

Journal reference:

Nature [DOI: 10.1038/s41586-024-08218-x](https://doi.org/10.1038/s41586-024-08218-x)

Breakthrough in reversible computing technology promises to solve the computing industry's energy crisis



[Pendulum Curve, 1899-1910, Frederick H. Evans, Public Domain](#)

In today's computers, when we switch a transistor from 0 to 1, we charge it up (requiring energy), and when we're done, we discharge it, losing all that energy as heat. It's like filling a bucket with water only to immediately dump it out.

The computing industry faces a looming energy crisis as the skyrocketing demand for power from data centers, AI systems, and edge devices strains electrical grids and challenges sustainability goals

As reported in [IEEE Spectrum](#), Vaire Computing has found a way to save computational energy using what they call a resonator system. "It's kind of like a swinging pendulum," explains Hannah Earley, Vaire's chief technology officer of the reversible computing startup. Instead of just dumping the energy, they capture and reuse it.

Here's how it works:

1. When computing needs to happen, electrical energy charges the circuit (pendulum swings up)
2. The computation occurs at the peak of the swing
3. Instead of letting the energy dissipate as heat, it's captured as the pendulum swings back down
4. This recovered energy is used for the next computation

"On each upswing, one computational step is performed. On each downswing, a decomputation is performed, recovering the energy," the *IEEE Spectrum* article explains. The system uses special slowly-ramping voltage patterns (called adiabatic switching) to minimize energy loss during these transitions.

While some energy is still lost (just as a real pendulum eventually stops swinging due to friction), the system can be remarkably efficient. Vaire's upcoming MEMS-based resonator is expected to achieve 99.97% energy recovery.

"In principle, this allows [us], over the next 10 to 15 years, to get to 4,000x improvement in performance," says Earley.

Huawei's \$2,800 trifold phone is a real thing it wants people to hold and use

"It's a piece of work that everyone has thought of but never managed to create."

[KEVIN PURDY](#) – SEP 10, 2024

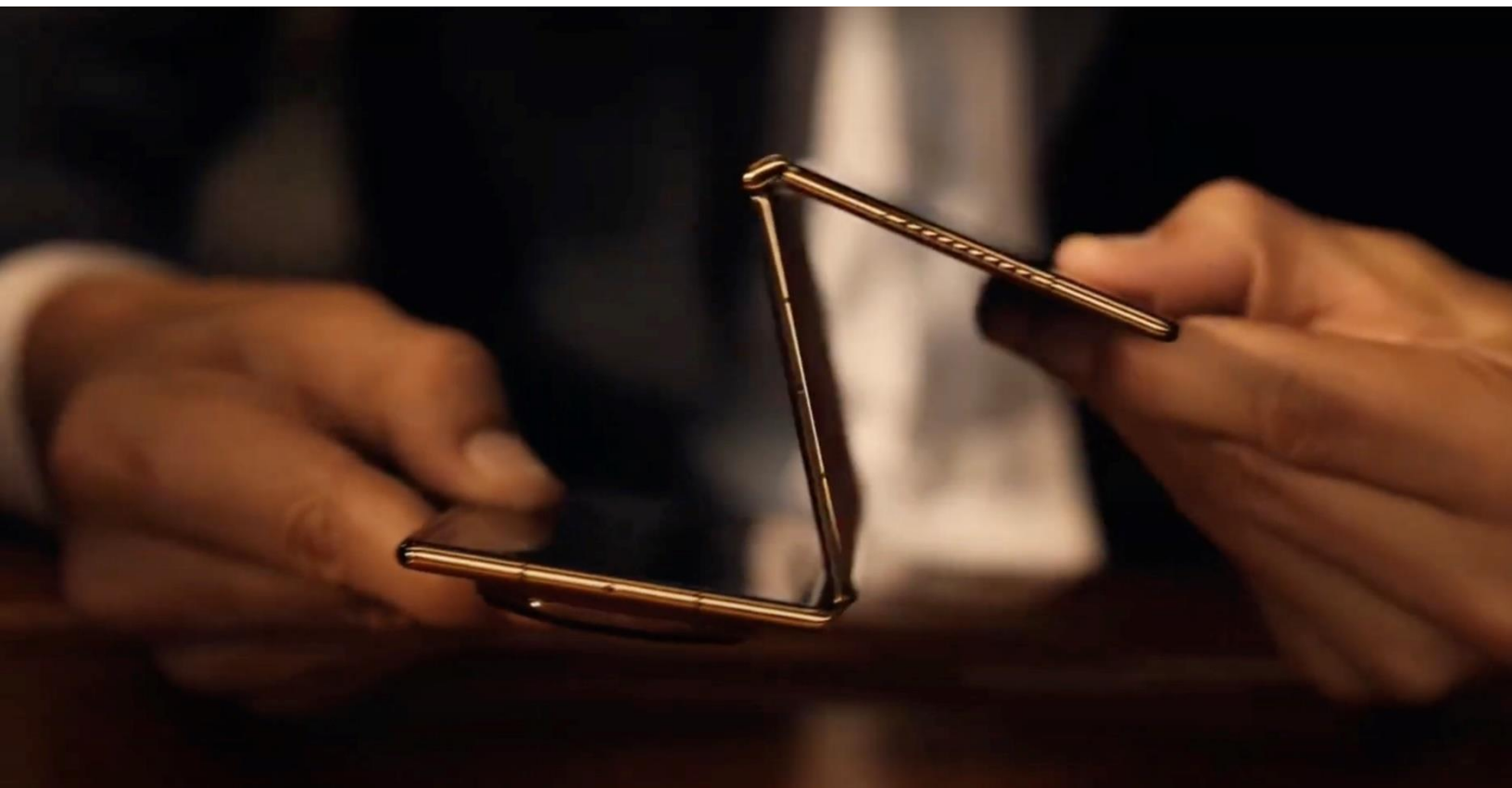
In the U.S., a folding phone has you carrying around nearly \$2,000 of fragile, folding OLED phone. In China and export-friendly countries, the Mate XT adds \$1,000 and yet another hinge. Credit: Huawei

[Huawei's Mate XT Ultimate](#) is a phone that does not flip or fold, at least in the way of its [Samsung](#) or [Google](#) contemporaries. You could say it collapses, really, across two hinges, from a full 10.2-inch diagonal rectangle (about a half-inch short of a standard iPad) down to a traditional 6.4-inch rectangle phone slab. There's also an in-between single-fold configuration at 7.9 inches. And there's an optional folding keyboard.

This phone, which Huawei calls a "trifold," would cost you the USD equivalent of \$2,800 (19,999 yuan) if you could buy it in the US. Most notably, the phone launched just hours after [Apple's iPhone 16 event](#). As noted by The New York Times, Huawei's product launches are often timed for maximum pushback against the US, which has [sanctioned](#) and [attempted to stymie Huawei's chip tech](#).

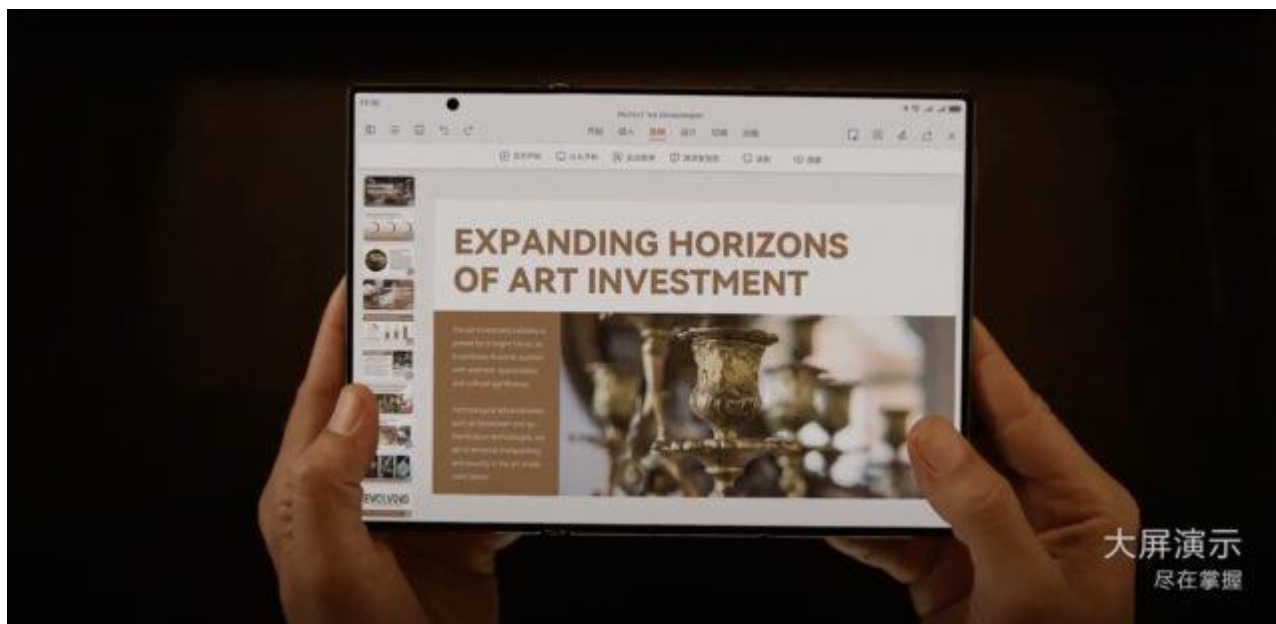
ADVERTISING

"It's a piece of work that everyone has thought of but never managed to create," Richard Yu, Huawei's consumer group chairman, said during the Mate XT livestream unveiling. "I have always had a dream to put our tablet in my pocket, and we did it."



The Mate XT looks incredibly thin on all three panels. You can seemingly unfold the whole thing, or do just two panels. **Huawei**





If you can afford the \$2,800 Mate XT, a first-generation trifold phone, you can survive every one of your holdings being in the red today.

Alternately, you can afford the Mate XT because you are at an "investing in art" level of wealth. **Huawei**



For the price of [two really good gaming PCs](#), you get 256GB storage (with pricier upgrades available), 16GB RAM, a 5,600 mAh battery, a 50-megapixel main camera, and two 12 MP ultrawide and periscope cameras. It weighs 298 grams, is just 3.6 mm thick when unfolded, and its screen is an LTPO OLED with 120 Hz refresh. There are, just like US flagship phones, a lot of AI-powered promises stuck onto the software and camera.

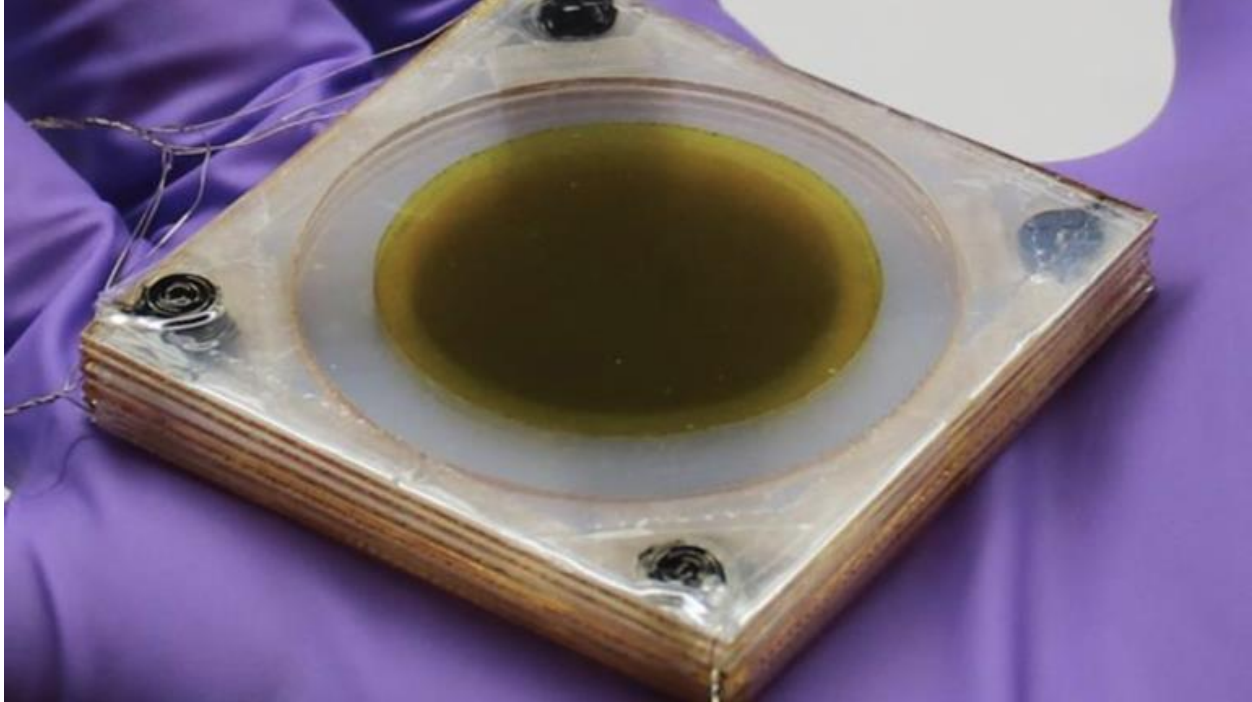


The "Tiangong" hinge system inside the Mate XT Ultimate. Credit: Huawei

Beyond the price, the size, and the AI promises, the Mate XT Ultimate will be most interesting in how its hinges hold up. Huawei named its hinges after the [Tiangong space station](#) and says it allows for "internal and external bending" across dual tracks. It is made of a composite laminate and non-Newtonian fluid bits.

[The Verge notes](#) that the Mate XT Ultimate has seen some 3.7 million pre-orders through Chinese retailer Vmall—before a price was announced. It does not seem likely that the phone will be released outside China.

Cooling pump made of thin films drops temperatures by 16 degrees, can transform wearables



Cooling pump made of thin films drops temperatures by 16 degrees, can transform wearables

A new cooling innovation developed by scientists pumps away heat continuously using layers of flexing thin films. The design is based on the electrocaloric effect, in which an electric field causes a temporary change in a material's temperature, according to researchers.

Developed by UCLA materials scientists, the prototype could lower ambient temperatures of its immediate surroundings by 16 degrees Fahrenheit continuously and up to 25 degrees at the source of the heat after about 30 seconds during lab experiments.

Qibing Pei, a professor of materials science and engineering at the UCLA Samueli School of Engineering, stated that their long-term goal is to develop this technology for wearable cooling accessories that are comfortable, affordable, reliable and energy-efficient — especially for people who work in very hot environments over long hours.

Material is composed of a circular stack of six thin polymer films

“As average temperatures continue to rise with climate change, coping with heat is becoming a [critical](#) health issue. We need a variety of solutions to the problem and this could be the basis for one,” added Pei.

Scientists revealed that the experimental material is composed of a circular stack of six thin polymer films, just under an inch in diameter and one-quarter of an inch thick for the entire stack. Each layer is coated with [carbon nanotubes](#) on both sides. The resulting material is ferroelectric, which means it changes shape when an electric field is applied.

When the device’s electric field is switched on, the stacked layers compress against each other in pairs. When the electricity switches off, the stacked pairs come apart to then press against the other neighboring layers. As this alternating process repeats itself, the self-regenerative, accordion-like cascading action continually pumps heat away, layer by layer, according to a [press release](#).

Polymer films use a circuit to shuttle charges

Hanxiang Wu, one of the study’s co-lead authors and a postdoctoral scholar working in Pei’s lab, stated that the [polymer films](#) use a circuit to shuttle charges between pairs of stacked layers, which makes the flexible cooling device more efficient than air conditioners.

Scientists maintained that traditional cooling technology relies on air conditioning and refrigeration, which require vapor compression that not only consumes a great deal of energy but also uses carbon dioxide as a coolant. The new device is a simpler design that does not require greenhouse-gas-generating coolants or liquids. It operates solely with electricity, which can be sustainable when generated through renewable energy sources such as solar panels, [as per](#) the release.

Wenzhong Yan, a postdoctoral scholar in mechanical engineering, stated that this cooling device integrates advanced materials with an elegant mechanical architecture to deliver energy-efficient [cooling](#) by embedding functionality directly into its structure, reducing complexity, energy use and computational demands.

Pei highlighted that electrocaloric cooling would be most-ideal for next-generation wearables that can keep us cool under strenuous conditions. "It could also be used to cool electronics with flexible components," said Pei.

This Dell Monitor Comes With Invisible Headphones



Illustration of someone experiencing beamforming audio with the Dell 32 Plus 4K QD-OLED Monitor.

Need a monitor that does it all? Dell is preparing to launch the 32 Plus 4K QD-OLED Monitor, a compelling product for laptop owners who want a simple yet powerful desktop experience.

Equipped with a 31.5-inch Quantum Dot OLED panel, the Dell 32 Plus 4K QD-OLED Monitor produces high-resolution images with deep contrast and 99% DCI-

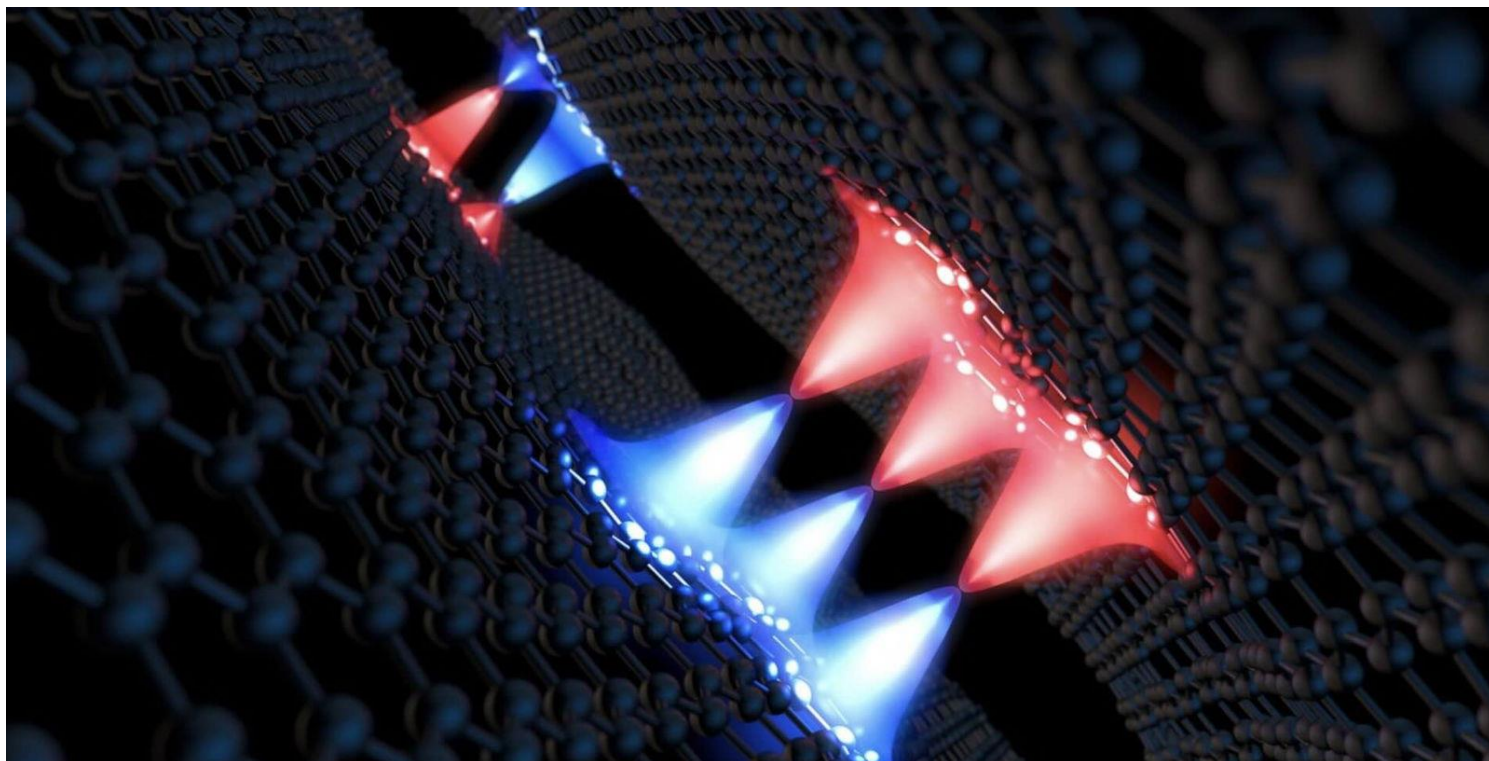
P3 color gamut coverage. It also supports Dolby Vision and HDR TV400, meaning that it should be a fantastic option for video consumption and creative work.

Gaming should feel great on this monitor, too, as it supports [FreeSync Premium](#) and boasts a 120Hz refresh rate with a 0.03ms response time.

More notably, the monitor packs a pair of 5-watt speakers with "AI-enhanced 3D Spatial Audio" technology." That's a fancy way of saying that it has an integrated soundbar with surround sound virtualization. The thing that I find interesting about these integrated speakers is their use of [beamforming technology](#) and head tracking. Dell claims that the speakers will "follow your every move" and utilize destructive interference to create an exceptionally wide soundstage. In theory, this technology should be akin to an invisible pair of headphones, though I haven't tested Dell's implementation and can't attest to its quality at this time.

Fancy "3D Spatial Audio" speakers may seem like overkill in a desktop monitor. So, I should take this opportunity to reiterate that the Dell 32 Plus QD-OLED Monitor is designed for laptop owners who need a simple, clean, powerful, all-in-one desktop solution. There's just one HDMI port on this puppy, as the user is expected to plug in via USB-C. Connected laptops receive 90-watt passthrough charging from the monitor, there's an extra USB-C port on the monitor's backside for accessories, and a pop-out module in the monitor's chin provides additional USB-C and USB-A inputs.

The [Dell 32 Plus QD-OLED Monitor](#) (S3225QC) launches globally on February 25th. At \$700, it's the same price as Dell's new UltraSharp 27 4K Thunderbolt Hub monitor, which has a far greater port selection than the Dell 32 Plus QD-OLED but uses a slightly worse display panel and doesn't offer any fancy audio technology.



EXCITONS DEMONSTRATE EXCITING QUANTUM MYSTERIES WITH POTENTIAL FOR REVOLUTIONARY COMPUTING POWER

[RYAN WHALEN](#) · JANUARY 10, 2025

The unpredictable quantum world just got stranger thanks to Brown University physicists and the discovery of unexpected behavior in particles called fractional excitons.

Odd quantum behaviors like existing in multiple locations simultaneously, instantaneous communication over large distances, and passing through solid barriers have long intrigued physicists. Now, the recent Brown University discoveries are shedding light on what seemingly impossible properties exist at the tiny quantum scale.

MY LATEST VIDEOS

“Our findings point toward an entirely new class of quantum particles that carry no overall charge but follow unique quantum statistics,” [said co-author Jia Li](#), an associate professor of physics at Brown. “The most exciting part is that this discovery unlocks a range of novel quantum phases of matter, presenting a new frontier for future research, deepening our understanding of fundamental physics, and even opening up new possibilities in quantum computation.”

QUANTUM EFFECTS

In 1879, American physicist Edwin Hall discovered the Hall effect, in which a magnetic field applied to a material with an electric current generates measurable voltage differences at right angles to both the magnetic field and the current. Today, the Hall effect is an important component in engineering video game controllers.

At the [quantum level](#), the quantum Hall effect occurs, where extremely low temperatures contrasted with high magnetic fields enable the “sideways” voltage to increase in distinctly separate jumps. Even stranger is the fractional quantum Hall effect, where those steps grow by only a fraction of an electron’s charge.

The Brown team developed a structure from two pieces of the two-dimensional nanomaterial graphene insulated from each other with hexagonal boron nitride crystal. This platform allowed the researchers to finely control electrical charges and create excitons. The physicists created the excitons by combining an electron with a hole, the absence of an electron. With the excitons prepared, the team then exposed the system to magnetic fields millions of times stronger than Earth’s to observe the strange characteristics of novel fractional excitons.

UNEXPECTED PARTICLES

The excitons that the Brown team observed defied typical categorization. Generally, fundamental particles are either bosons or fermions. Bosons can share the same quantum state and co-exist with others of their kind, while no two fermions can occupy the same state due to the Pauli exclusion principle. A far smaller number of particles fit into the anyon category, which lies somewhere in the middle. The fractional excitons, however, displayed behaviors specific to each while not entirely resembling any type, acting almost as a hybrid.

“This unexpected behavior suggests fractional excitons could represent an entirely new class of particles with unique quantum properties,” lead author Naiyuan Zhang said. “We show that excitons can exist in the fractional quantum Hall regime and that some of these excitons arise from the pairing of fractionally charged particles, creating fractional excitons that don’t behave like bosons.”

QUANTUM COMPUTING APPLICATIONS

This new type of particle isn’t just a scientific curiosity; it may have very important real-world applications. These particles could enhance information storage and manipulation, improving the speed and reliability of quantum computers.

“We’ve essentially unlocked a new dimension for exploring and manipulating this phenomenon, and we’re only beginning to scratch the surface,” Li said. “This is the first time we’ve shown that these types of particles exist experimentally, and now we are delving deeper into what might come from them.”

Moving forward, the Brown physicists are working to understand how these particles can be applied to real-world uses. The team’s next study will focus on how the fractional excitons interact and how humans can effectively control their behavior. A thorough understanding of their behavior could lead to exciting applications in

the quantum computing field, while tighter control will be required to execute those ideas.

“This feels like we have our finger right on the knob of quantum mechanics,” co-author D. E. Feldman said. “It’s an aspect of quantum mechanics that we didn’t know about or, at least, we didn’t appreciate before now.”

“The paper “[Excitons in the Fractional Quantum Hall Effect](#)” appeared on January 08, 2025 in *Nature*.

Ryan Whalen covers science and technology for The Debrief. He holds an MA in History and a Master of Library and Information Science with a certificate in Data Science. He can be contacted at ryan@thedebrief.org, and follow him on Twitter [@mdntwvlf](https://twitter.com/mdntwvlf).

Virginia Tech's breakthrough in flexible electronics tech

Scientists from Virginia Tech have developed a method for manufacturing flexible electronics. This technology can significantly impact the development of soft robots, interesting gadgets, and wearable electronics.

Virginia Polytechnic Institute and State University researchers presented their findings in the journal "Nature Electronics." They introduced an innovative approach to creating flexible printed circuit boards. Their method allows for efficient current flow between system layers without drilling holes, which is crucial for the miniaturization and flexibility of future electronics. Although commercial applications are still far off, this marks a new direction in developing flexible electronics.

The new technique relies on using liquid metal microparticles to create a stair-like structure. This architecture forms small, conductive connections both within and between circuit layers. The process involves the targeted placement of liquid metal droplets in a photosensitive resin, which is then illuminated with UV rays. This method remains versatile and can be adapted to various materials.

Soft electronics

"This brings us closer to exciting possibilities like advanced soft robotics, wearable devices, and electronics that can stretch, bend, and twist while **maintaining high functionality**," says project leader Prof. Michael Bartlett.

The research team harnessed typically undesirable effects that appear when working with UV-cured materials, known as mask edge anomalies. They turned this problem into an advantage—the edges of UV-exposed areas cause the liquid metal droplets to settle and layer up in a stair-like pattern.

"By leveraging these otherwise unwanted edge effects, we can create soft, conductive vias that connect different circuit layers in a rapid and parallel fashion. We can do this all while maintaining flexibility and mechanical integrity of the soft device," explains the lead author of the publication, Dr. Dong Hae Ho.

Integrating connections both within and between layers enables the creation of soft, flexible circuits with a complex, multilayered architecture.

"This enables new forms of soft electronics, where multiple soft vias and interconnects are created in a parallel and spatially controlled manner. This is crucial for advancing the field," emphasizes Prof. Bartlett.

Flexible electronics may, for instance, offer a new approach to creating smartphones. Currently, manufacturers are focusing on foldable smartphones. In the future, they may consider using rollable screens. The first attempts have already been made with devices like the Motorola Rizr.

Korean breakthrough: Ultra-thin film absorbs 99% of EM waves

The material developed in Korea can absorb up to 99% of electromagnetic waves. A thin film with a thickness of just 0.02 inches is sufficient. Until now, screens have only absorbed about 10% of the radiation.



Base station (illustrative photo)

A research team from the Korea Institute of Materials Science (KIMS) has created an innovative material that, in the form of a thin film just 0.02 inches thick, absorbs up to 99% of electromagnetic waves. This solution can significantly help eliminate interference generated by such waves. The development represents a significant breakthrough compared to existing shielding materials, which have only allowed the absorption of about 10% of the radiation.

The new material can absorb electromagnetic waves over a wide range of frequencies, including those used in 5G, 6G technologies, and Wi-Fi networks. This feature is crucial in environments filled with sources of such waves. Proper shielding can eliminate interference, which can negatively affect the performance of nearby devices.

Absorption of electromagnetic waves

Traditional electromagnetic shielding materials often reflect over 90% of waves, meaning the actual absorption is minimal, around 10%. Additionally, materials with higher absorption typically only work in a narrow range of frequencies, limiting their versatility. According to reports, the invention by scientists at KIMS does not have these limitations. Its significant advantages include high effectiveness while maintaining minimal thickness and appropriate flexibility.

The process of creating the material involved modifying the crystal structure of ferrite, which was then combined with a thin polymer film. Special conductive patterns were applied to the backside, enabling the control of electromagnetic wave propagation. By adjusting the shape of the conductive patterns, the reflection of electromagnetic waves at specific frequencies can be significantly reduced.

In addition, a thin film of carbon nanotubes was applied to the back of the material. These have a high shielding value, and this process is intended to further enhance the performance of the developed shielding material.

The material developed by the Korean researchers maintains its shape even after repeated bending and straightening. Scientists claim it can be bent thousands of times. For this reason, it is well-suited for applications in mobile devices, such as foldable smartphones or wearable devices.

"As 5G/6G communication applications expand, the importance of materials that absorb and shield electromagnetic waves grows. This material has great potential to improve the reliability of communication devices, such as smartphones and autonomous vehicle radars," said project leader Byeongjin Park.

Optical Interposers Could Start Speeding Up AI in 2025

Fiber-optic cables are creeping closer to processors in high-performance computers, replacing copper connections with glass. Technology companies hope to speed up AI and lower its energy cost by moving optical connections from outside the server onto the motherboard and then having them sidle up alongside the processor. Now tech firms are poised to go even further in the quest to multiply the processor's potential—by slipping the connections underneath it.

That's the approach taken by Lightmatter, which claims to lead the pack with an interposer configured to make light-speed connections, not just from processor to processor but also between parts of the processor. The technology's proponents claim it has the potential to decrease the amount of power used in complex computing significantly, an essential requirement for today's AI technology to progress.

Lightmatter's innovations have attracted the attention of investors, who have seen enough potential in the technology to raise US \$850 million for the company, launching it well ahead of its competitors to a multi-unicorn valuation of \$4.4 billion. Now Lightmatter is poised to get its technology, called Passage, running. The company plans to have the production version of the technology installed and running in lead-customer systems by the end of 2025.

Passage, an optical interconnect system, could be a crucial step to increasing computation speeds of high-performance processors beyond the limits of Moore's Law. The technology heralds a future where separate processors can pool their resources and work in synchrony on the huge computations required by artificial intelligence, according to CEO Nick Harris.

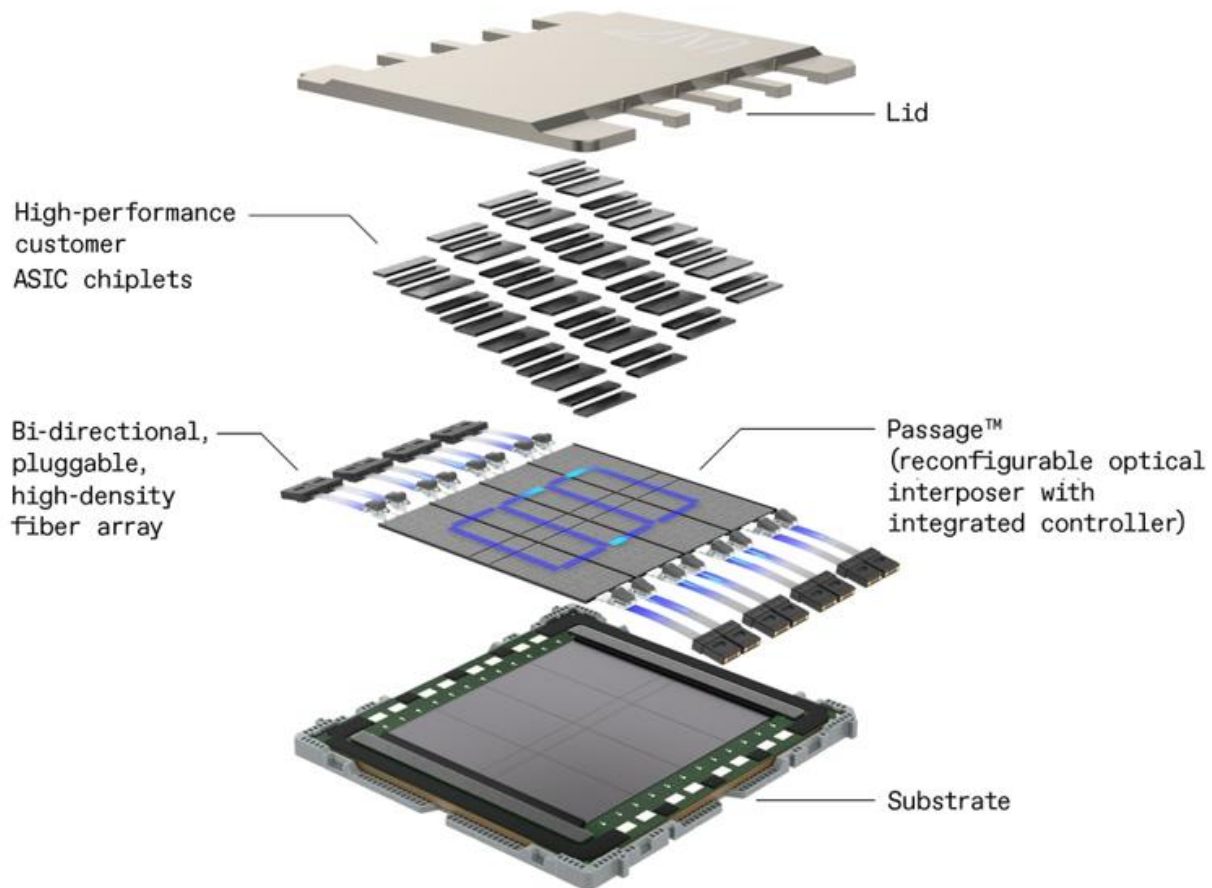
"Progress in computing from now on is going to come from linking multiple chips together," he says.

An Optical Interposer

Fundamentally, Passage is an interposer, a slice of glass or silicon upon which smaller silicon dies, often called chiplets, are attached and interconnected within the same package. Many top server CPUs and GPUs these days are composed of multiple silicon dies on interposers. The scheme allows designers to connect dies made with different manufacturing technologies and to increase the amount of processing and memory beyond what's possible with a single chip.

Today, the interconnects that link chiplets on interposers are strictly electrical. They are high-speed and low-energy links compared with, say, those on a motherboard. But they can't compare with the impedance-free flow of photons through glass fibers.

Passage is cut from a 300-millimeter wafer of silicon containing a thin layer of silicon dioxide just below the surface. A multiband, external laser chip provides the light Passage uses. The interposer contains technology that can receive an electric signal from a chip's standard I/O system, called a serializer/deserializer, or SerDes. As such, Passage is compatible with out-of-the-box silicon processor chips and requires no fundamental design changes to the chip.



Four roughly rectangular shaped objects stacked atop each other. The second from the top is in pieces.

Computing chiplets are stacked atop the optical interposer. Lightmatter

From the SerDes, the signal travels to a set of transceivers called [microring resonators](#), which encode bits onto laser light in different wavelengths. Next, a multiplexer combines the light wavelengths together onto an optical circuit, where the data is routed by interferometers and more ring resonators.

From the [optical circuit](#), the data can be sent off the processor through one of the eight fiber arrays that line the opposite sides of the chip package. Or the data can be routed back up into another chip in the same processor. At either destination, the process is run in reverse, in which the light is demultiplexed and translated back into electricity, using a photodetector and a transimpedance amplifier.

Passage can enable a data center to use between one-sixth and one-twentieth as much energy, Harris claims.

The direct connection between any chiplet in a processor removes latency and saves energy compared with the typical electrical arrangement, which is often limited to what's around the perimeter of a die.

That's where Passage diverges from other entrants in the race to link processors with light. Lightmatter's competitors, such as [Ayar Labs](#) and [Avicena](#), produce optical I/O chiplets designed to sit in the limited space beside the processor's main die. Harris calls this approach the "generation 2.5" of optical interconnects, a step above the interconnects situated outside the processor package on the motherboard.

Advantages of Optics

The advantages of photonic interconnects come from removing limitations inherent to electricity, which expends more energy the farther it must move data.

Photonic interconnect startups are built on the premise that those limitations must fall in order for future systems to meet the coming computational demands of artificial intelligence. Many processors across a data center will need to work on a task simultaneously, Harris says. But moving data between them over several meters with electricity would be "physically impossible," he adds, and also mind-bogglingly expensive.

"The power requirements are getting too high for what data centers were built for," Harris continues. Passage can enable a data center to use between one-sixth and one-twentieth as much energy, with efficiency increasing as the size of the data center grows, he claims. However, the energy savings that [photonic interconnects](#) make possible won't lead to data centers using less power overall, he says. Instead of scaling back energy use, they're more likely to consume the same amount of power, only on more-demanding tasks.

AI Drives Optical Interconnects

Lightmatter's coffers grew in October with a \$400 million Series D fundraising round. The investment in optimized processor networking is part of a trend that has become "inevitable," says [James Sanders](#), an analyst at [TechInsights](#).

In 2023, 10 percent of servers shipped were accelerated, meaning they contain CPUs paired with GPUs or other AI-accelerating ICs. These accelerators are the same as those that Passage is designed to pair with. By 2029, TechInsights projects, a third of servers shipped will be accelerated. The money being poured into photonic interconnects is a bet that they are the accelerant needed to profit from AI.

World's first scalable, networked photonic quantum computer prototype unveiled



World's first scalable, networked photonic quantum computer prototype unveiled

Traditional computers rely on electrons to perform computational tasks, but electrons can never match the speed and processing power offered by photons, tiny packets of light that travel at an astonishing 300,000 km/s.

Unfortunately, we cannot make classical computers run on photons because they need electric charges to process and store information. On the other hand, [photons](#) are chargeless and do not interact easily with electronic components like transistors in classical circuits.

This is why scientists have been trying to develop [photonic quantum computers](#), an advanced computing concept that uses mirrors, beam splitters, and optical fibers to manipulate photons.

However, the word “concept” in the above paragraph seems to be no longer required as a Canada-based quantum computing company named Xanadu has created the world’s first scalable and networked photonic quantum computer prototype.

“It is the very first time we—or anyone, for that matter—have combined all the subsystems necessary to implement universal and fault-tolerant quantum computation in a photonic architecture.” the Xanadu team [said](#).

A practical photonic quantum system

Xanadu calls their [photonic quantum computer](#) Aurora. It is a 12-qubit system developed using four independent modular server racks, which in total comprise 35 photonic chips and 13-km (8-mile) long fiber optics. The best part is that this entire system operates in room-temperature conditions.

Aurora’s makers claim that it is highly scalable and equipped with everything needed to perform fault-tolerant quantum computing operations.

It currently works like a baby data center but, in principle, it could “be scaled up to thousands of server racks and millions of qubits today, realizing the ultimate goal of a big quantum data center,” the Xanadu team notes.

The study authors also tested their four-server computer to create a special type of entangled state with billions of modes. This result was collected over 2 hours and represents the creation and measurement of a large entangled state, made up of 86.4 billion modes, or about 7.2 billion temporal modes.

“We use this machine, which we name Aurora, to synthesize a cluster state entangled across separate chips with 86.4 billion modes, and demonstrate its capability of implementing the foliated distance-2 repetition code with real-time decoding,” authors of a peer-reviewed study on Aurora [said](#).

In quantum computing, a repetition code is a straightforward approach to dealing with errors. It works by encoding a single logical qubit across several physical qubits, creating redundancy for easy detection and correction of errors.

The test successfully proved Aurora's potential for performing complex and large computations in a [fault-tolerant manner](#).

Aurora isn't yet perfect

There's no doubt that Aurora is a highly scalable and modular photonic computer, but its design still has some challenges to overcome.

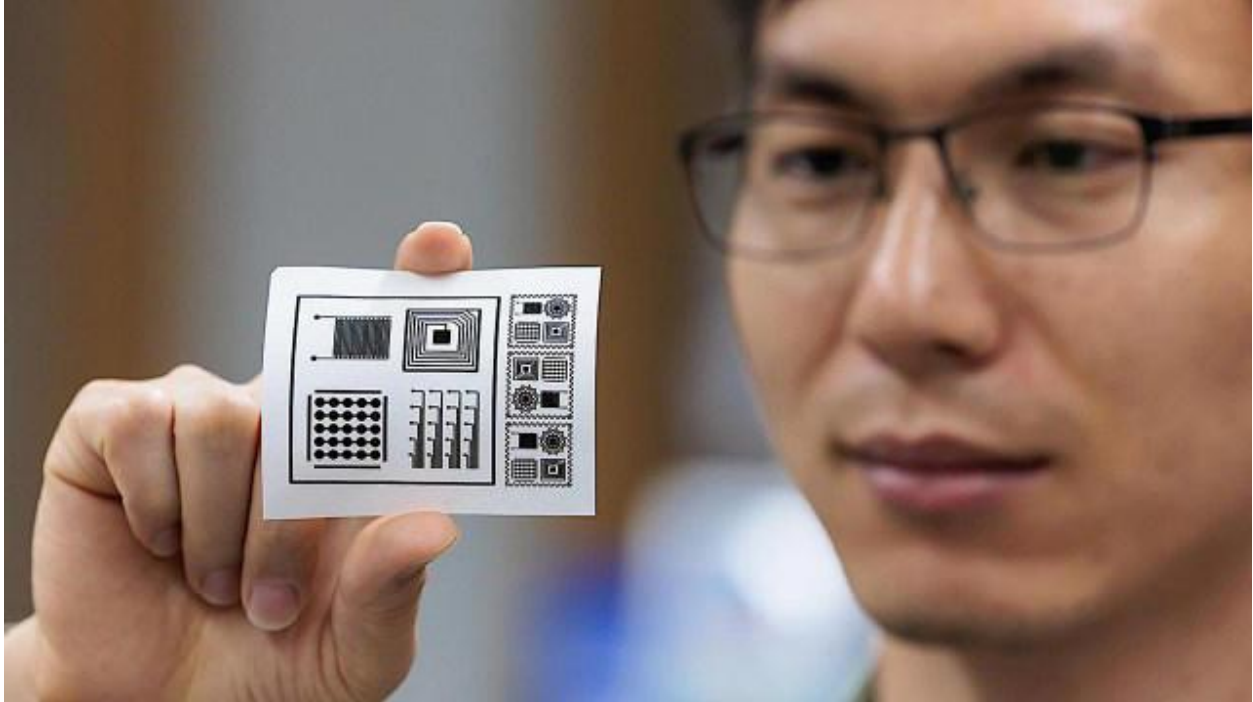
For instance, when it is scaled to the size of a large data center, it is likely to encounter high signal loss rates and need a large number of [more complex hi-tech](#) components to function smoothly.

"Loss rates will still have to come down by orders of magnitude as the resulting system will need to be the size of a conventional data center to operate," Christoph Simon, a quantum computing expert at the University of Calgary, [told](#) *The Globe and Mail*. Simon wasn't a part of the Xanadu team.

It will still take some years before all the challenges with Aurora are met, but the good news is photonic quantum computing is off to a solid start. In the coming months, we could see the development of more advanced systems with a larger number of servers.

A [study](#) on Aurora is published in the journal *Nature*.

Scientists unveil gecko-inspired process to solve destructive computer issue: 'A major step forward'



Scientists unveil gecko-inspired process to solve destructive computer issue: 'A major step forward'

Researchers at the University of Chicago may have found a way to make circuits that doesn't involve abrasive chemicals, according to [TechXplore](#).

Photolithography is the way people typically build the transistors that are vital to everyday electronics. This process involves shining light through a template and onto a photosensitive material on the other side. An array of [harmful chemicals](#) are then applied that can latch onto the areas that react with the light.

This new method uses laser etching instead of lithography, and most importantly has been able to replace harsh chemicals with water to achieve comparable effects.

"Using water instead of toxic solvents is a major step forward," said study co-author Chuanwang Yang. "We see this being particularly useful for devices that don't need the extreme precision of silicon chips but still require high functionality."

"The combination of sustainable substrates and hazards-free processing substantially lowers greenhouse gas emissions and reduces environmental impacts for device fabrication compared with traditional microfabrication methods," said [the paper](#), which also suggests this method can reduce energy consumption and production time.

Besides the potential applications and reduced environmental footprint, the inspiration for the [technology](#) is noteworthy. Study co-author Bozhi Tian said they took a hint from how gecko feet stick and unstick from just about every surface type when developing their technique.

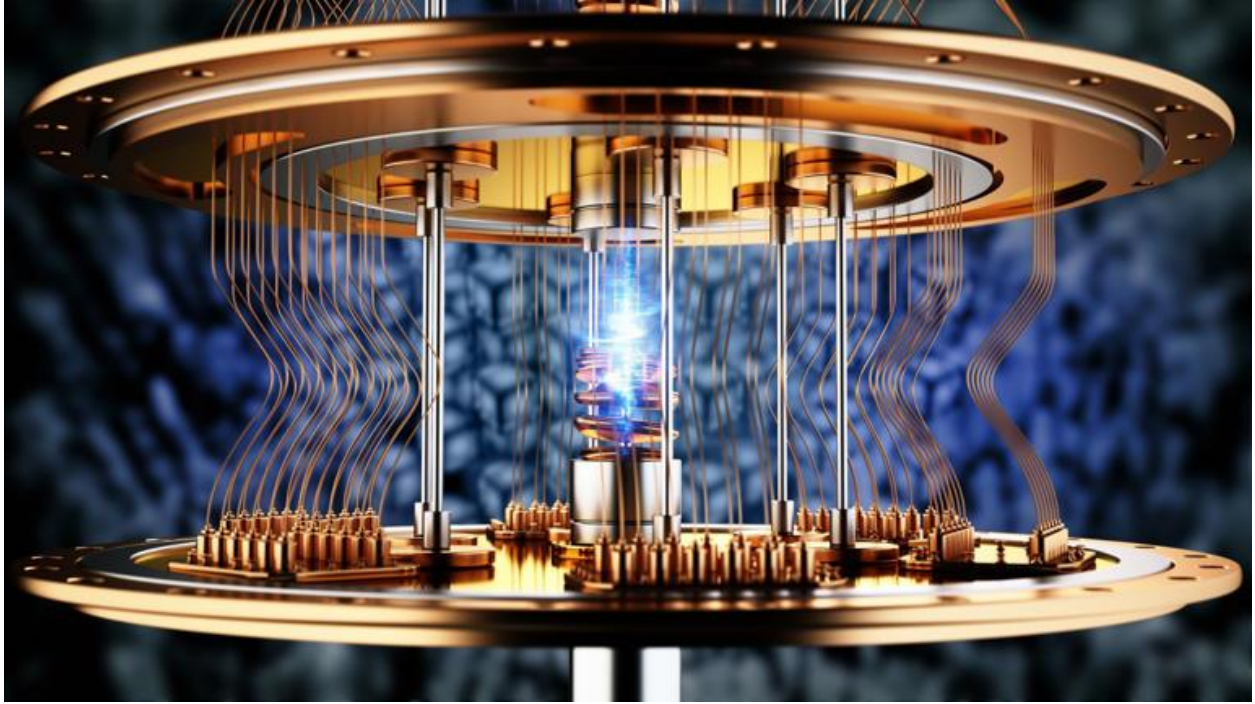
[Watch now: CEO reveals form of energy that has 'polled across political lines' for over a decade](#)

This isn't the first time cutting-edge electronics manufacturing methods have borrowed some ideas from nature. One study used tree leaves as an inspiration for [biodegradable circuits](#).

While we're unlikely to see this new method of circuit printing in our phones or computers, there's a wide range of devices that could dramatically lower their environmental impact by using this production method. Even for those niche use cases, it usually takes a few years for technology to graduate from the lab to the assembly line.

It may well be worth the wait, as we need all the help we can get on this front. Electronics manufacturing has cumulatively [produced half of our pollution](#).

Scientists demonstrate first-ever quantum error solving with dual codes



Scientists demonstrate first-ever quantum error solving with dual codes

Just like any machine, quantum computers are prone to make errors. These errors can cause the qubits to lose their quantum states, leading to inaccurate computations. To address this problem, quantum computers rely on special protocols called correction codes.

However, there is one big problem with this approach. No single correction code can ensure protection against all errors. This is why when more than one error pops up in a quantum system, the chances of its failure increase dramatically.

A team of European researchers has come up with an interesting solution to this problem.

In their latest study, they reveal a method that allows a quantum computer to [switch between two](#) different correction codes. This method will ensure the system performs all computing tasks in an error-free manner.

“No single error-correcting code intrinsically supports a fault-tolerant implementation of all the gates needed for universal quantum computing. One

approach for addressing this problem is to switch between two suitable error-correcting codes that in combination provide a fault-tolerant universal gate set," the study authors [note](#).

Solving errors in the quantum world is tricky

When it comes to classical computers, errors are often fixed using methods like redundancy (storing multiple copies of data) or error-detection techniques, which com However, quantum computers face a unique challenge. You cannot copy an unknown quantum state due to a fundamental rule of quantum mechanics called the [no-cloning theorem](#). This means quantum states cannot be saved or duplicated during calculations, making it impossible to detect errors by comparing copies of the same state.

To overcome this limitation, scientists developed a different approach. Instead of copying quantum states directly, they spread the quantum information across multiple entangled qubits. This allows errors to be detected and corrected without violating quantum rules.

The specific methods for distributing and protecting quantum information are described in protocols known as [quantum error correction codes](#). These codes enable quantum computers to operate reliably by ensuring that even if some qubits are affected by errors, the overall quantum information remains intact.

pare copies of data to identify and correct mistakes.

However, different quantum error [correction codes](#) also come with different difficulties. For instance, each code has a limit on how much noise or error it can handle. If the [errors in the system](#) exceed this threshold, the correction code won't work.

Nevertheless, a quantum system can encounter different types of errors, such as bit-flips, phase-flips, or some combinations of these. This is why no single correction code can implement all the gate operations and protect against all the errors.

A dual-code approach

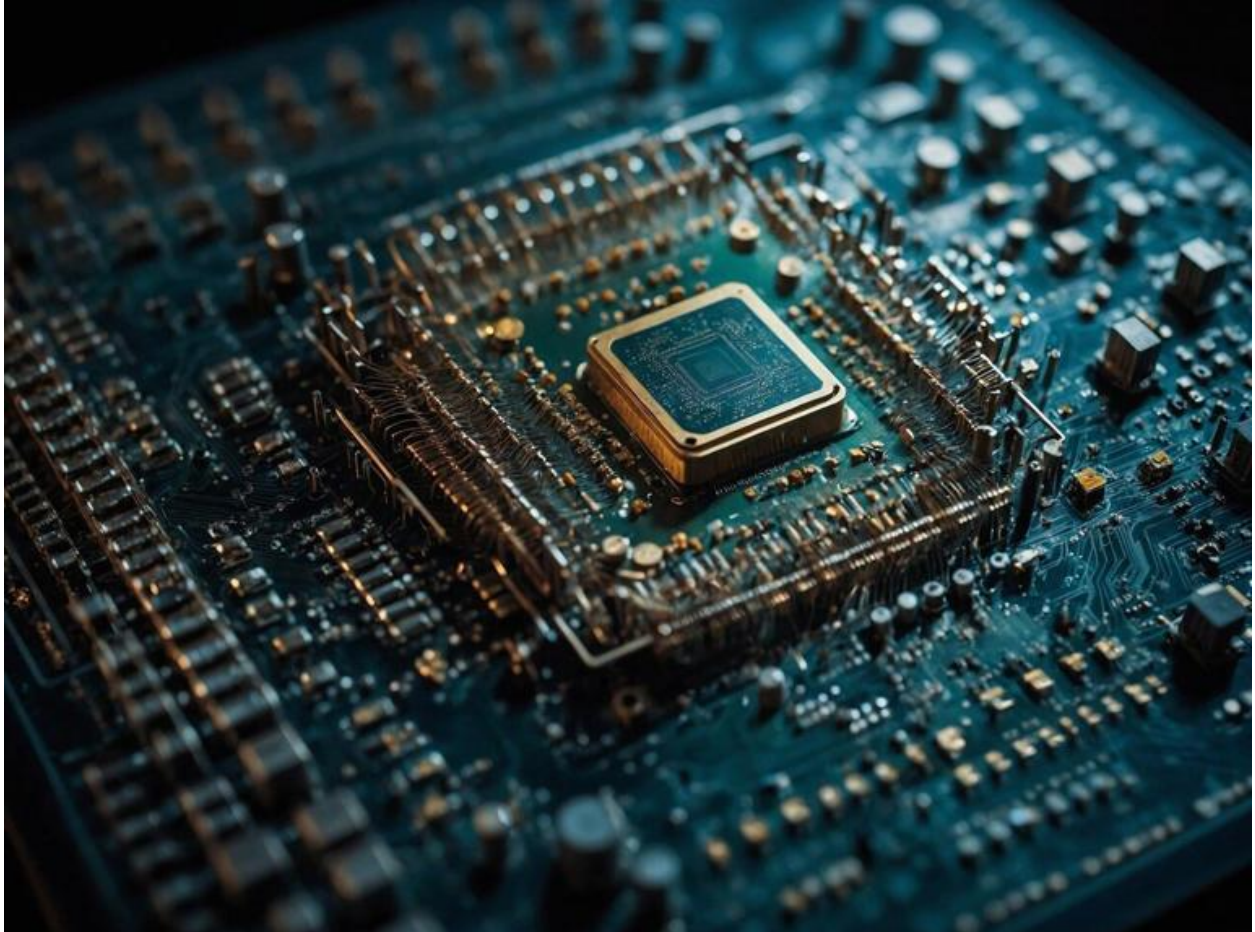
The study authors constructed a unique quantum circuit using a full universal gate set on an [ion-trap quantum computer](#). In this setup, they introduced fault-tolerant code-switching between two different codes and prepared 12 distinct logical states that cannot be supported by a single correction code.

“We switch between the 7-qubit color code, which features fault-tolerant CNOT and H quantum gates, and the 10-qubit code, which allows for a fault-tolerant T gate implementation. Together, these codes form a complementary universal gate set,” the study authors said.

This is the first time scientists successfully demonstrated error solving in a quantum system using a combination of two correction codes. This breakthrough could contribute to the development of [error-free quantum computing](#) applications.

The [study](#) is published in the journal *Nature Physics*.

Next-generation computers: New wiring material could transform chip technology



The rapid technological advancements of our world have been enabled by our capacity to design and fabricate ever smaller electronic chips. These underpin computers, mobile phones and every smart device deployed to date.

One of the many challenges is that electronic components generate increasingly more heat as they are miniaturized. A significant issue lies in making the wires which connect the transistors on the chip thinner while ensuring that the minimum amount of heat is released.

These interconnects are typically made from copper, and as we start to scale them down to nano-scale thicknesses, their electrical resistance increases rapidly because the electrons moving along the wires have a higher probability of colliding into the surface of the wire. Known as scattering, this leads to energy being released in the form of waste heat, meaning you need more power to maintain the same level of performance.

A group at Stanford University has [published a new paper](#) showing that thin films of a material known as niobium phosphide (NbP) exhibit much higher conductivity than copper below a thickness of 5 nanometers (nm) (the typical thickness of the wiring in today's chips is about 10nm–30nm). This improvement is because NbP is a material with unique quantum properties.

NbP is in a class of materials known as topological materials, which have unique electronic properties due to their atomic structure and were the subject of the 2016 [Nobel prize in physics](#). Their conductivity along the surface is extremely high and stays the same regardless of changes to the shape or size of the material (physicists refer to this as a "topologically protected surface state").

In other words, it is robust and not easily destroyed by reshaping it. Even when the material is made thinner, bent or given ridges, the special conductive properties that can be observed on the surface remain present.

This is important, as the ability to decrease the thickness of the electrical interconnects while still allowing electricity to flow easily is key to balancing the fabrication cost and complexity against energy efficiency. This gives NbP a significant advantage over other materials.

Disorder vs. order

What is particularly remarkable about the discovery by the Stanford team is that these quantum properties were observed in disordered films, meaning the niobium phosphide wasn't fabricated in the most controlled way to maximize its conductive properties.

There's a good analogy in making bars of chocolate: it's vital to control the cooling process of melted chocolate to create the glossy end-product that you're used to. This process is known as tempering. Anyone who has tried this likely knows how dull and soft the untempered version can be—and how it affects the taste.

The difference between tempered and untempered chocolate is the size of the individual crystals within the chocolate's structure (or to put it another way, the amount of ordering). Untempered chocolate contains multiple small crystals that are disordered with respect to one another. To make tempered chocolate, a

manufacturer will cool it in a controlled way and also add a piece of tempered chocolate to promote the growth of a uniform crystal structure.

Now imagine how useful it would be if you could simply skip this tempering. Not only would it make the production process more efficient, it could also decrease the energy required. This is essentially what the Stanford team have shown in relation to their material.

To put it in technical terms, the niobium phosphide had no long-range order. This means that while it might have contained some of the small crystals that you would associate with an optimum version, the material was considered a disordered alloy overall.

Despite this, it was still an excellent conductor for an ultrathin film, seemingly due to the exotic quantum phenomenon of topologically protected surface states. If this effect can occur even in a disordered material, it greatly simplifies the manufacturing process—with positive implications for the costs.

This shows how quantum effects could lead to such significant improvements in conductivity, potentially enabling us to produce more powerful and energy-efficient computer chips in the near future. One important question is whether enough niobium phosphide could be available for manufacturing purposes.

While this is not our area, [phosphorus is almost](#) as plentiful as carbon in the Earth's crust, while niobium is about one third as plentiful as copper, roughly comparable with cobalt and nickel. That suggests sufficient supply, though specialists would have to weigh the relative cost of extracting these elements from their ores.

For those of us working in this field, the discovery also raises the question of whether other topological materials such as [tantalum phosphide](#) and [tantalum arsenide](#) could behave similarly. Also, what is the essential ingredient that the NbP samples possess for them to act in this way? These questions will continue to engage scientists in their search for solutions to enable lower-power computing technologies of the future.

New era for digital storage thanks to terahertz light

Published January 28, 2025 at 01:00 AM

Researchers at MIT have successfully induced a durable magnetic state in an antiferromagnetic material using terahertz light. This discovery could revolutionize magnetic storage technologies by making them resistant to external disturbances, thereby improving the performance of memory and processors.

The MIT team used a terahertz laser to directly influence the atoms of an antiferromagnetic material. By precisely tuning the laser's oscillations to match the natural vibrations of the material's atoms, they were able to alter the alignment of atomic spins, creating a new magnetic state. This innovative method opens up prospects for controlling and switching antiferromagnetic materials, which are essential for future information processing technologies.



Unlike ferromagnetics, where the spins of atoms are aligned in the same direction, antiferromagnetics have alternating spins, which cancels out their overall magnetization. This characteristic makes antiferromagnetics insensitive to external magnetic fields but also difficult to manipulate. The use of terahertz light overcomes

this limitation, offering a new way to control these materials.

The potential applications of this discovery are vast, particularly in the manufacturing of memory chips. Data could be stored in microscopic domains of the material, representing the '0' and '1' bits by specific spin configurations. This technology promises increased robustness against magnetic interference, reduced energy consumption, and improved storage density.

The material used in this study, FePS₃, undergoes a transition to an antiferromagnetic phase at a critical temperature. By exciting the atomic vibrations of the material with terahertz light, the researchers were able to disrupt the spin alignment, inducing a new magnetic state. This transition persisted for several milliseconds after the laser was turned off, providing a time window to study the properties of this state.

This research paves the way for new techniques to manipulate quantum materials, with potential implications for information and communication technologies. The ability to induce and maintain magnetic states in antiferromagnetics could lead to significant advancements in data storage and information processing.

The work of the MIT team, published in *Nature*, demonstrates the effectiveness of terahertz light in manipulating the magnetic properties of antiferromagnetic materials. This approach could be extended to other quantum materials, offering new perspectives for fundamental research and technological applications.

What is terahertz light?

Terahertz light lies in a part of the electromagnetic spectrum between microwaves and infrared. It is characterized by frequencies oscillating between 0.1 and 10 terahertz, corresponding to wavelengths ranging from 3 mm to 30 μm .

This light is particularly interesting for scientific research because it can interact with the atomic and molecular vibrations of materials. Unlike X-rays or ultraviolet light, terahertz light is non-ionizing, meaning it does not cause damage to biological or electronic materials.

Applications of terahertz light are vast, ranging from medical imaging to security, and including wireless communications. In the field of quantum materials, it offers a non-invasive method to manipulate electronic and magnetic properties at the atomic scale.

Why are antiferromagnetics difficult to manipulate?

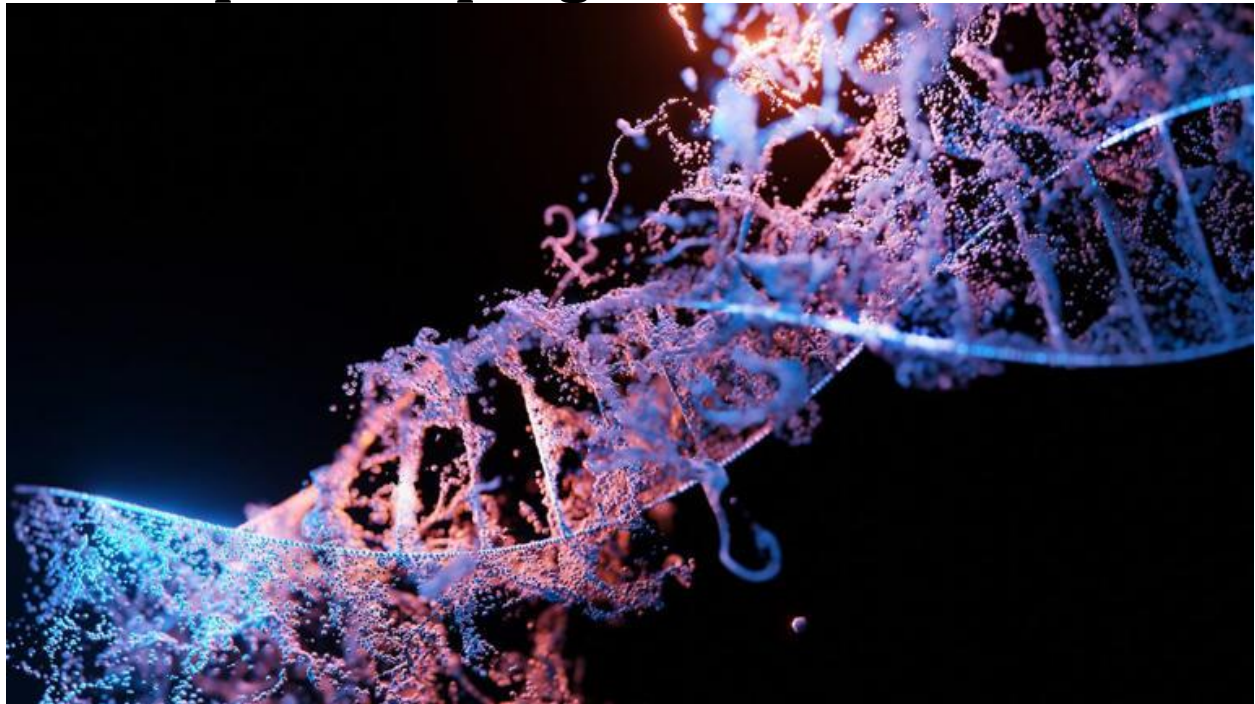
Antiferromagnetic materials are composed of atoms with alternating spins, meaning they point in opposite directions. This configuration cancels out the overall magnetization of the material, making it insensitive to external magnetic fields.

This insensitivity is both an advantage and a disadvantage. On one hand, it makes

antiferromagnetics robust against magnetic disturbances, which is ideal for applications requiring high stability. On the other hand, it makes these materials difficult to control and manipulate, limiting their use in current technologies.

The MIT discovery, using terahertz light to induce a magnetic state in an antiferromagnetic material, opens new possibilities for overcoming these limitations. By precisely adjusting the frequency of the light to match the atomic vibrations of the material, the researchers were able to disrupt the spin alignment, creating a new magnetic state.

DNA-based supercomputer can run 100 billion parallel programs



DNA-based programmable gate arrays could revolutionize medical diagnostics and computing. (CREDIT: CC BY-SA 4.0)© The Brighter Side of News

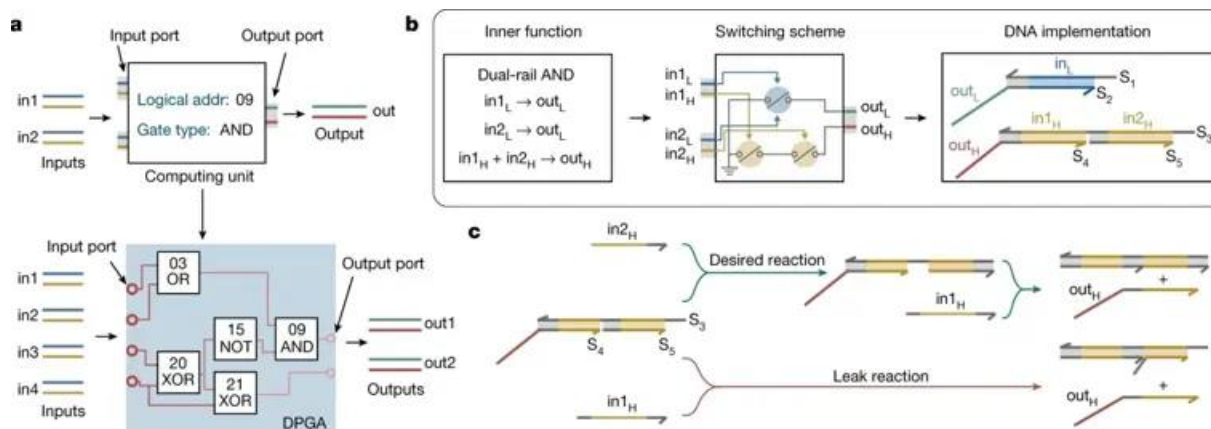
The boundaries of computer technology are being redefined as biology merges with electronics. At the forefront of this evolution lies an innovative concept—a liquid computer powered by DNA. With the capacity to support over 100 billion unique circuits, this revolutionary system might soon reshape medical diagnostics and disease detection.

DNA, known as the foundation of life, carries the genetic code for all living organisms. However, a research team led by Dr. Fei Wang at [Shanghai Jiao Tong University](#) is exploring DNA's potential as a computational element.

Their research was recently published in the journal [Nature](#). In their vision, DNA molecules act not just as the carriers of genetic information but also as wires, instructions, and even electrons within computer circuits.

In traditional computers, electrons follow predefined paths on [silicon chips](#) to execute commands. The more complex the operation, the more intricate the pathways. Dr. Wang's team, however, sought a biological alternative to traditional silicon-based design.

They explored how short DNA segments could combine into larger molecular structures capable of functioning as circuit components. These structures could serve as wires or even guide molecular wiring for stable connections.



Uniform dual-rail computing units with logic-gated DNA-UTS transmission. (CREDIT: Nature)© The Brighter Side of News

The researchers filled test tubes with DNA strands suspended in a buffer fluid, enabling them to interact and form complex molecules through chemical reactions. Fluorescent markers embedded in these molecules allowed scientists to monitor the activity of the [DNA circuits](#) by observing the glowing parts.

The Rise of DNA-Based Programmable Arrays

The cornerstone of this innovation lies in DNA-based programmable gate arrays (DPGA). These programmable arrays, assembled from single-stranded DNA

oligonucleotides, allow for highly scalable and adaptable circuits. Each DPGA supports over 100 billion unique configurations, allowing scientists to customize its functionality by introducing specific short molecules.

In one experiment, the team connected three DPGAs, using approximately 500 DNA strands, to build a circuit capable of solving quadratic equations. Another circuit was designed to calculate square roots. Input molecules interacted with the [DNA circuit](#) much like electrons travel through wires in conventional electronics. The resulting chemical reactions produced output molecules whose fluorescent glow allowed researchers to decode the results.

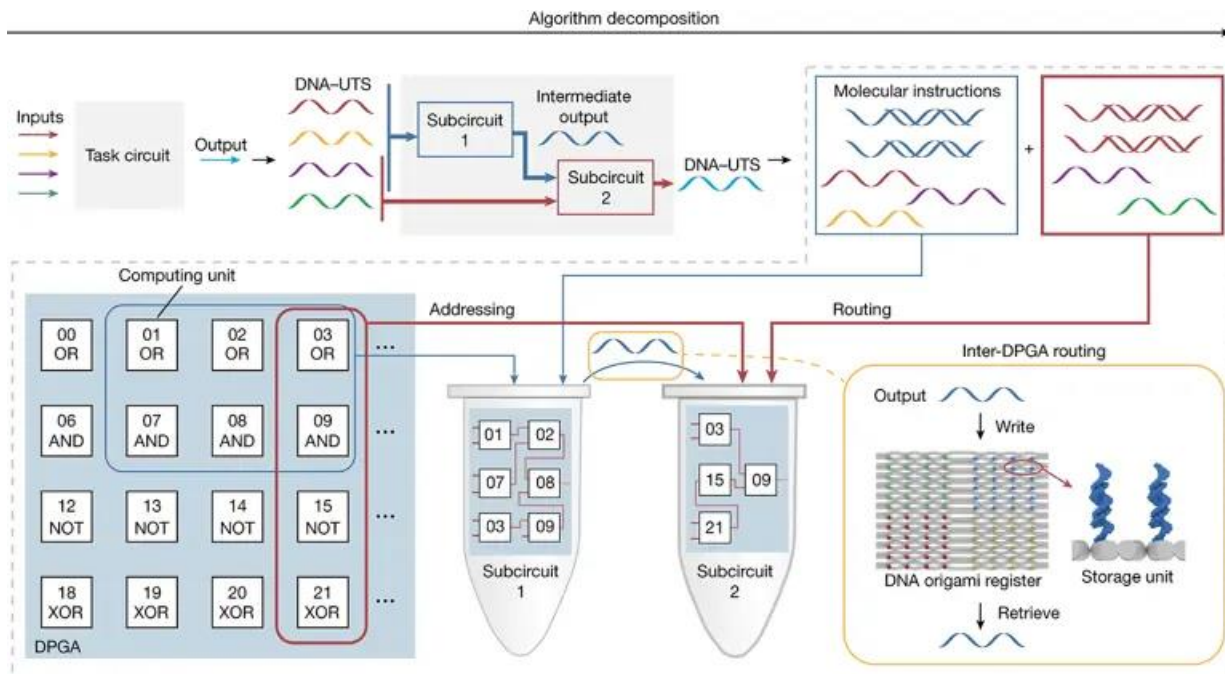
This innovative approach draws inspiration from field-programmable gate arrays (FPGAs) in silicon-based computing. FPGAs enable [reconfiguration of circuits](#) for diverse applications. Similarly, DPGAs offer programmability and scalability but operate within liquid-phase environments.

Unlike traditional circuits, where electrons move directionally, biomolecular components in liquid DNA systems diffuse and mix randomly, posing unique challenges. The researchers overcame these hurdles by introducing spatial compartmentalization to enhance directionality and scalability.

Revolutionizing Medical Diagnostics

While mathematical computations demonstrate the potential of DNA-based computing, its most transformative application lies in [medical diagnostics](#).

Dr. Wang's team developed a DPGA capable of distinguishing between different small RNA molecules, including those associated with renal cancer. This achievement underscores the potential for DNA computing in detecting disease at the molecular level.



DNA's inherent compatibility with biological systems makes it a natural fit for medical diagnostics. "DPGA-based diagnostic devices would be highly parallel and energy-efficient," Dr. Wang explained. By harnessing DNA's ability to interact with biological molecules, these circuits can perform [intelligent diagnostics](#), identifying disease markers in complex biological samples.

For example, the team's diagnostic circuit processed molecular inputs from RNA samples and identified the presence of cancer-related molecules through chemical reactions. The results were encoded in fluorescent signals, offering a straightforward method for detection. This capability positions DNA circuits as tools for [real-time disease monitoring](#) and personalized medicine.

Despite the groundbreaking achievements, DNA computing remains in its early stages. Challenges such as random molecular collisions and scalability limitations need to be addressed. Current DNA systems, while programmable, require further refinement to match the versatility of electronic circuits.

However, the potential applications are vast. DNA circuits could revolutionize healthcare by enabling seamless disease detection. Imagine a diagnostic device capable of identifying diseases from a simple blood or saliva sample based on the glow of molecules. This technology could pave the way for minimally invasive, efficient, and accurate diagnostics, transforming medical practices worldwide.

Dr. Wang remains optimistic about the future of DNA computing. He envisions a time when DPGA technology will enable intelligent diagnostic tools embedded within living systems. Such advancements could [detect diseases](#) at their earliest stages, offering unprecedented opportunities for intervention.

A Glimpse into the Future

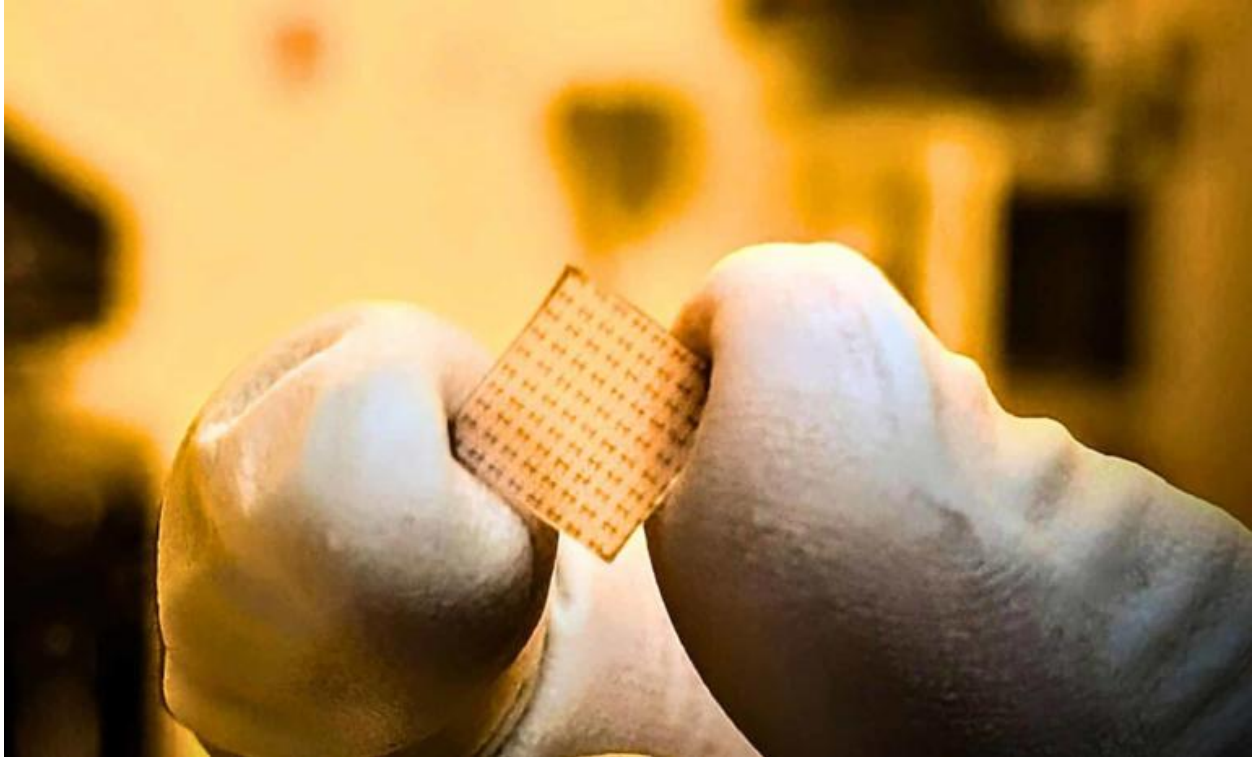
The convergence of biology and electronics offers a glimpse into the future of computing and healthcare. As scientists continue to push the boundaries of DNA computing, its applications may extend beyond medicine to fields such as environmental monitoring, synthetic biology, and artificial intelligence.

This innovative technology represents a paradigm shift in computation, leveraging the [properties of DNA](#) to solve complex problems in ways traditional systems cannot. With continued research, DNA-based programmable arrays could redefine the landscape of diagnostics, computation, and beyond.

Dr. Wang's work exemplifies the transformative potential of interdisciplinary research. By combining principles of biology, chemistry, and computer science, his team has opened new avenues for innovation.

As the technology matures, its impact could be profound, offering solutions to some of humanity's most pressing challenges.

The U.S. Discovers a Groundbreaking Material That Could Replace Copper in Electronics, Slashing Energy Costs



The U.S. Discovers a Groundbreaking Material That Could Replace Copper in Electronics, Slashing Energy Costs | The Daily Galaxy --Great Discoveries Channel© Daily Galaxy

For over a century, **copper** has been the undisputed king of electrical conductivity. From power grids to the smallest microchips, it has fueled technological revolutions. But what if everything we thought we knew about conductivity was about to change?

Researchers at **Stanford University** have just made a discovery that could shatter the foundations of the electronics industry. **Niobium phosphide**, a little-known material, has proven itself superior to copper at the nanoscale. This breakthrough could mark the beginning of the end for copper and the dawn of a new era in electronics.

Why copper is in trouble

Copper has long been the go-to material for conducting electricity due to its excellent conductivity and abundance. But there's a fatal flaw: as devices shrink, copper starts to **fail**.

At the nanoscale, where wires are only **a few atoms thick**, copper struggles with **increased resistance**, **energy loss**, and [heat generation](#). This bottleneck has become a nightmare for engineers desperately trying to push the limits of **miniaturization and performance**.

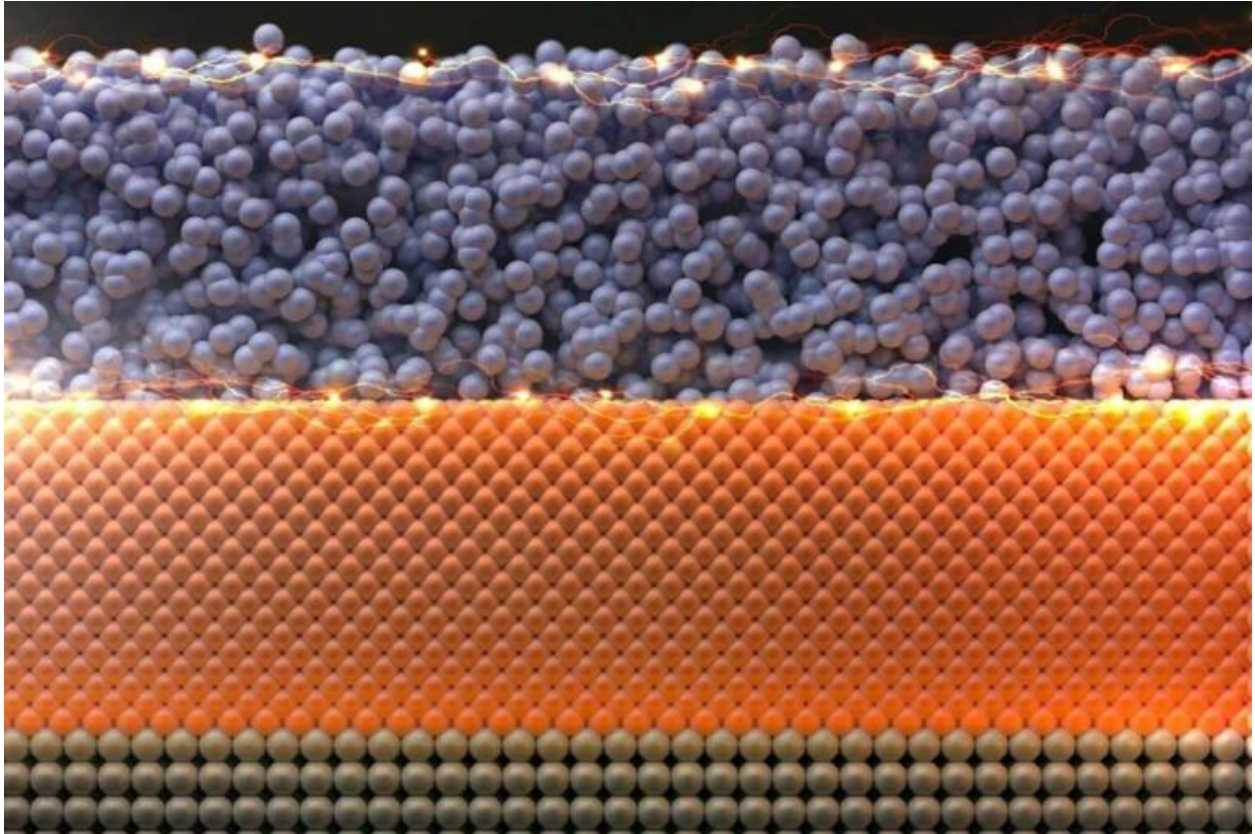
And that's where **niobium phosphide** comes in—offering a way out of this crisis.

A material that defies expectations

The Stanford team has found that niobium phosphide can **outperform copper** in ultra-thin films of less than **5 nanometers**. Unlike copper, which loses efficiency as it shrinks, **this material maintains its high conductivity**.

The implications are enormous:

- **Extreme efficiency at the nanoscale** – It works where copper fails.
- **Less heat, more reliability** – Devices stay cooler, reducing risks of overheating and extending lifespan.
- **Easier to manufacture** – Unlike exotic alternatives, niobium phosphide integrates seamlessly with existing silicon-based chip manufacturing.



A film a few atoms thick of non-crystalline niobium phosphide conducts better through the surface to make the material, as a whole, a better conductor. | Il-Kwon Oh / Asir Khan© Daily Galaxy

What does this mean for the future of electronics?

If adopted, **niobium phosphide** could transform the **electronics industry**:

- **Faster, more efficient microchips** – With **less energy loss**, processors could become more powerful while using less power.
- **Longer battery life** – Smartphones and **wearable devices** could run significantly longer before needing a charge.
- **High-speed data transmission** – Technologies like **5G** and **AI computing** could operate with greater efficiency.

While niobium phosphide may not immediately replace copper, its unique properties make it a **strong candidate** for the **next generation** of **high-performance electronics**.

The end of copper? Or just the beginning?

This isn't just about one new material—it's about a technological shift. Researchers are already exploring other topological semimetals that could push efficiency even further.

The electronics industry is at a **crossroads**. Stick with aging copper and its limitations? Or embrace a new era of **smaller, faster, and more efficient** devices?

One thing is clear: **copper's days at the top are numbered**. The revolution is coming, and **niobium phosphide** is leading the charge.

Plastic supercapacitors could solve energy storage problems



Illustration of a PEDOT film on a graphene sheet that can be used in supercapacitors to store large amounts of energy. Credit: Maher El-Kady

Plastics have shaped our modern world and changed the way we live. For decades, they have been primarily used in electronics for their excellent insulating properties. But in the 1970s, scientists accidentally discovered that some plastics can also conduct electricity. This finding revolutionized the field and opened the door to applications in electronics and energy storage.

One of the most widely used electroconductive plastics today is called PEDOT, short for poly(3,4-ethylenedioxythiophene). PEDOT is a flexible, transparent film often applied to the surfaces of photographic films and electronic components to protect them from static electricity. It is also found in touch screens, organic solar cells and electrochromic devices, such as smart windows that switch from light to dark at the press of a button.

However, PEDOT's potential for energy storage has been limited because commercially available PEDOT materials lack the electrical conductivity and surface area needed to hold large amounts of energy.

UCLA chemists are addressing these challenges with an innovative method to control the morphology of PEDOT to grow nanofibers precisely. These nanofibers exhibit exceptional conductivity and expanded surface area, both of which are crucial for enhancing the energy storage capabilities of PEDOT.

This approach, described in a paper [published](#) in *Advanced Functional Materials*, demonstrates the potential of PEDOT nanofibers for supercapacitor applications.

Unlike batteries, which store energy through slow chemical reactions, supercapacitors store and release energy by accumulating electrical charge on their surface. This allows them to charge and discharge extremely quickly, making them ideal for applications requiring rapid bursts of power, such as regenerative braking systems in hybrid and electric vehicles and camera flashes. Better supercapacitors are, therefore, one route to reduced dependence on fossil fuels.

The UCLA chemists produced the new material through a unique vapor-phase growth process to create vertical PEDOT nanofibers. These nanofibers, resembling dense grass growing upward, dramatically increase the material's surface area, allowing it to store more energy. By adding a drop of liquid containing graphene oxide nanoflakes and ferric chloride on a graphite sheet, the researchers exposed this sample to a vapor of the precursor molecules that eventually formed the PEDOT polymer.

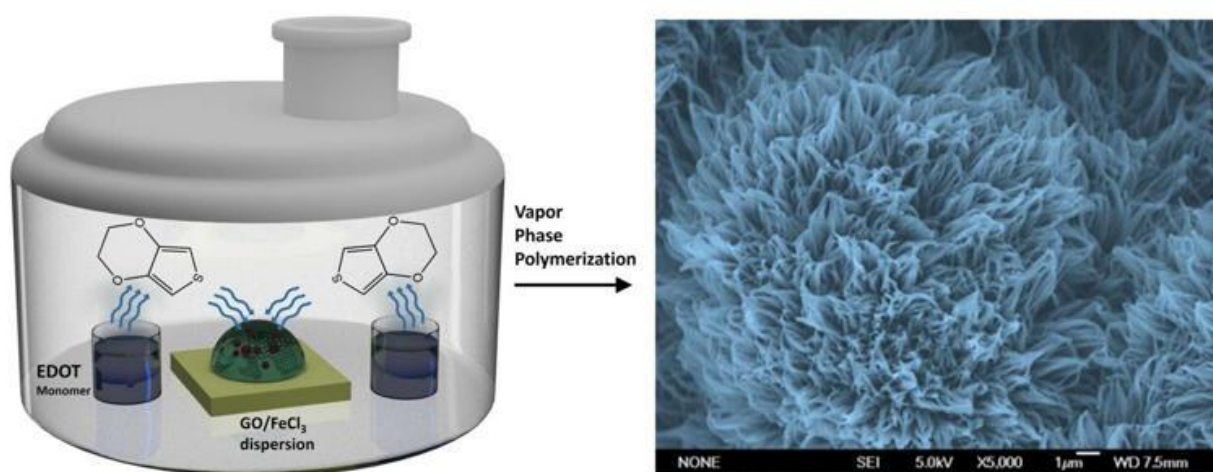
Instead of developing into a very thin, flat film, the polymer grew into a thick, fur-like structure, significantly increasing the surface area compared to conventional PEDOT materials.

"The material's unique vertical growth allows us to create PEDOT electrodes that store far more energy than traditional PEDOT," said corresponding author and UCLA materials scientist Maher El-Kady. "Electric charge is stored on the surface of the material, and traditional PEDOT films don't have enough surface area to hold very much charge. We increased the surface area of PEDOT and thereby increased its capacity enough to build a supercapacitor."

The authors used these PEDOT structures to fabricate supercapacitors with excellent charge storage capacity and extraordinary cycling stability, reaching nearly 100,000 cycles. The advance could pave the way for more efficient energy storage systems, directly addressing global challenges in renewable energy and sustainability.

"A polymer is essentially a long chain of molecules built out of shorter blocks called monomers," said El-Kady. "Think of it like a necklace made from individual beads strung together. We heat the liquid form of the monomers inside a chamber. As the vapors rise, they react chemically when they come in contact with the surface of the graphene nanoflakes. This reaction causes the monomers to bond and form vertical nanofibers. These nanofibers have a much higher surface area, which means they can store much more energy."

The new PEDOT material has shown impressive results, exceeding expectations in several critical areas. Its conductivity is 100 times higher than that of commercial PEDOT products, making it far more efficient for charge storage. What's even more remarkable is that the electrochemically active surface area of these PEDOT nanofibers is four times greater than that of traditional PEDOT. This increased surface area is crucial because it allows for much more energy to be stored in the same volume of material, significantly boosting the performance of supercapacitors.



An example of how EDOT monomer vapors react with a droplet of graphene oxide and ferric chloride to form PEDOT nanofibers. Credit: Maher El-Kady and Musibau Jimoh

Thanks to the new process, which grows a thick layer of nanofibers on the graphene sheet, this material now has one of the highest charge storage

capacities for PEDOT reported to date—more than 4,600 milliFarads per square centimeter, which is nearly one order of magnitude higher than conventional PEDOT.

On top of that, the material is incredibly durable, lasting through more than 70,000 charging cycles, far outlasting traditional materials. These advances open the door for supercapacitors that are not only faster and more efficient but also longer-lasting, which are essential qualities for the renewable energy industry.

"The exceptional performance and durability of our electrodes shows great potential for graphene PEDOT's use in supercapacitors that can help our society meet our energy needs," said corresponding author Richard Kaner, a UCLA distinguished professor of chemistry and of materials science and engineering, whose research team has been at the forefront of conducting polymer research for over 37 years.

As a doctoral student, Kaner contributed to the discovery of electrically conductive plastic by his advisors Alan MacDiarmid and Alan Heeger, who later received a Nobel Prize for their work. Other authors on the study include Musibau Francis Jimoh, Gray Carson and Mackenzie Anderson, all of whom are also at UCLA.

More information: Musibau Francis Jimoh et al, Direct Fabrication of 3D Electrodes Based on Graphene and Conducting Polymers for Supercapacitor Applications, *Advanced Functional Materials* (2024). [DOI: 10.1002/adfm.202405569](https://doi.org/10.1002/adfm.202405569)

Provided by University of California, Los Angeles

Altermagnetism: First conclusive evidence of an elusive third class of magnetism found

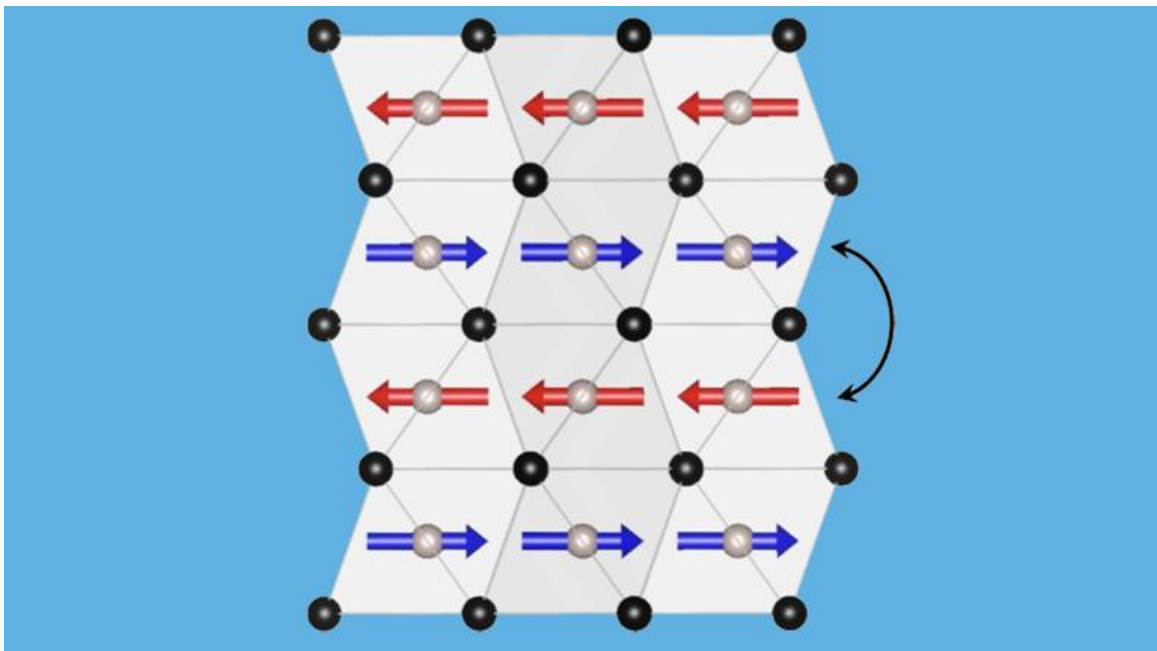
Magnetism plays a crucial role in enabling various applications, ranging from memory storage devices to advanced medical imaging, energy-efficient electric motors, magnetic sensors, and emerging quantum technologies.

For a long time, it has been believed that magnetism is of only two types; ferromagnetism and anti-ferromagnetism.

Both forms have their own importance, for instance, [without ferromagnets](#) one cannot imagine speakers, telephones, generators, hard drives, etc. Whereas anti-ferromagnetism is essential for various types of sensors, detectors, and quantum computing applications.

However, there's a hidden third type also [known as altermagnetism](#). This was first proposed in 2022, however, no solid evidence was found at the time. Now a proof-of-concept study shows that altermagnetism exists for

real. **Detecting altermagnetism in manganese telluride**



Magnetic moment

The type of [magnetism a material exhibits](#) is decided by the spin of its electrons. If the magnetic moments resulting from the spins are in the same direction, a material is ferromagnetic. However, if magnetic moments are in the opposite direction, it indicates antiferromagnetism.

The magnetic moment refers to the strength and direction of the magnetic field a material produces.

The study authors suggest that when it comes to altermagnetism, the magnetic moments of adjacent atoms are aligned in opposite directions, but they are not perfectly antiparallel. Instead, they are slightly tilted or exhibit a complex alignment due to [time-reversal symmetry breaking](#) (when the reverse of a process doesn't appear the same as the original).

The study authors noticed altermagnetism when they used photoemission electron microscopy (PEEM) to study manganese telluride (MnTe). PEEM involves using X-rays to eject electrons from the surface of a material, and then image those electrons to reveal several properties of the material.

The researchers used X-rays with different polarizations to hit MnTe. For instance, when a circularly polarized light struck the material, it highlighted MnTe's unique magnetic regions, or domains, caused by time-reversal symmetry breaking.

Whereas, when horizontally or vertically polarized X-rays were used, they revealed the orientation of magnetic moments, within the material. Surprisingly, when the study authors combined the results from these events, they noticed altermagnetic states.

"We demonstrate nanoscale imaging of altermagnetic states from 100-nanometre-scale vortices and domain walls to 10-micrometer-scale single-domain states in manganese telluride (MnTe)," the study authors [said](#).

The power of altermagnetism

Altermagnetism is an unusual and rarely observed phenomenon but it combines the best characteristics of ferromagnetism and antiferromagnetism.

For instance, altermagnets have “the speed and resilience of an antiferromagnet, but they also have this important property of ferromagnets called time-reversal symmetry breaking,” Alfredo Dal Din, one of the study authors and a postdoc researcher at the University of Nottingham, [told](#) *Live Science*.

A combination of such properties could lead to many exciting developments. For example, the study authors suggest that altermagnets have the potential to boost the speed of microelectronic components by a thousand times.

Plus, they can lead to the development of advanced magnetic applications and help scientists realize powerful phenomena such as [superconductivity](#).

“Our experimental work has provided a bridge between theoretical concepts and real-life realization, which hopefully illuminates a path to developing altermagnetic materials for practical applications,” Oliver Amin, first author of the study and a senior research fellow at Nottingham University, said.

The [study](#) is published in the journal *Nature*.

World's first scalable, connected, photonic quantum computer prototype developed



Schematic diagram of the Aurora system and main modules. Credit: *Nature* (2025). DOI: 10.1038/s41586-024-08406-9

A team of engineers, physicists and computer specialists at Canadian company, Xanadu Quantum Technologies Inc., has unveiled what they describe as the world's first scalable, connected, photonic quantum computer prototype.

In their paper [published](#) in the journal *Nature*, the group describes how they designed and built their modularized quantum computer, and how it can be easily scaled to virtually any desired size.

As scientists around the world continue to work toward the development of a truly useful quantum computer, makers of such machines continue to come up with design ideas. In this new effort, the research team built a quantum computer based on a [modular design](#). Their idea was to build a single basic box using just a few qubits for the simplest of applications. As the need arises, another box can be added, then another and another—with all the boxes working together like a network, as a single computer.

As each box, or quantum server rack, is added, the [processing power](#) grows. The team further suggests that thousands of racks could be tied together via fiber cables, creating a

massive quantum computer with massive processing abilities. What's more, the researchers have made the entire system photon-based, eliminating the need to connect photon-based parts with traditional electron-based parts.

To test their ideas, the researchers built a prototype—a network of four server racks using 84 [squeezers](#), which resulted in a computer with 12 physical qubits. The first rack is somewhat different than the other three.



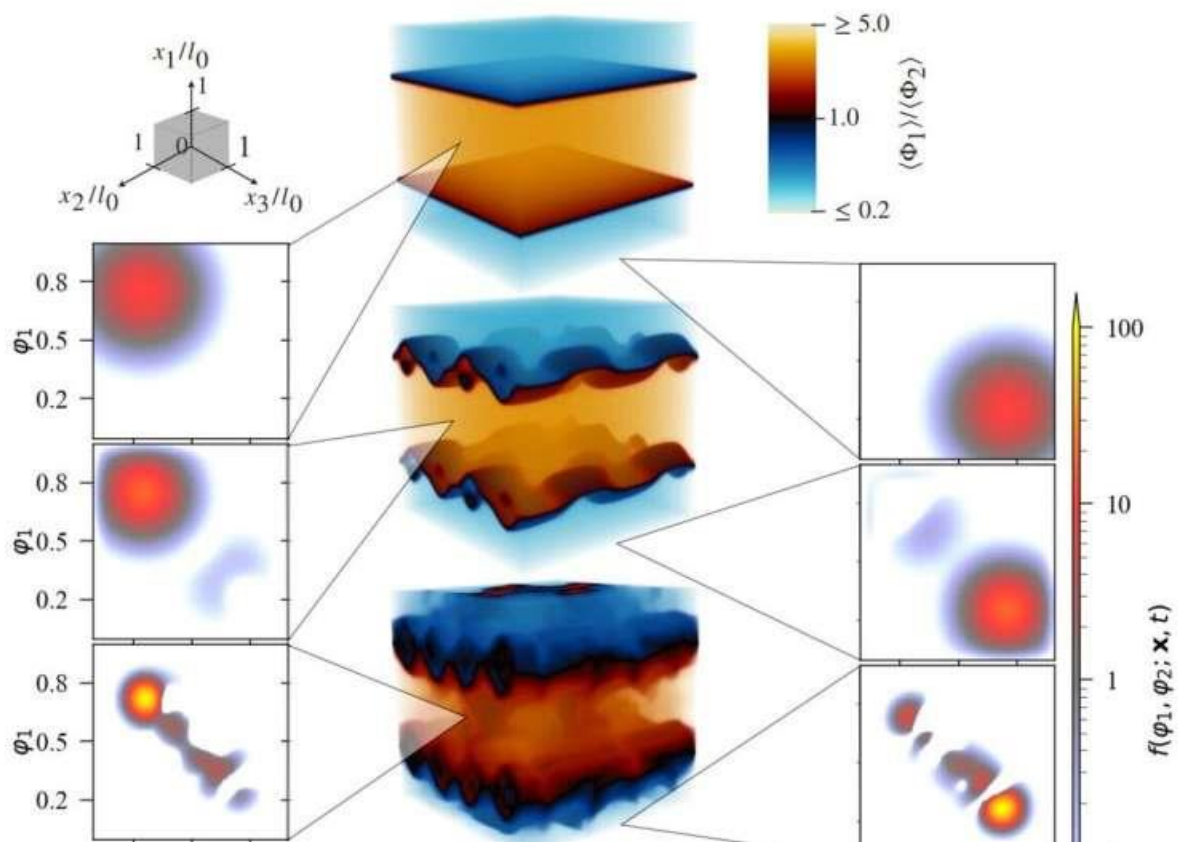
Photograph of the Aurora system. Credit: *Nature* (2025). DOI: 10.1038/s41586-024-08406-9
It holds the input lasers while the other three house quantum components divided into five main subsystems: sources, where the photon-based qubits are created; a buffering system that stores the qubits; a refinery that multiplexes the [qubits](#) to improve quality and create entangled qubit pairs; routing, which assists with entanglement and clustering; and the QPU, which creates finished spatial links in cluster states and carries out other functions. They also note that because the system is entirely photonic, it does not need to be cooled—it runs at room temperature.

The research team tested their system by creating a unique type of entangled state with billions of modes and were pleased with the results, suggesting that they showed their system is capable of carrying out complex and large-scale computations with a high degree of fault tolerance.

JANUARY 29, 2025

Quantum-inspired computing drives major advance in simulating turbulence

by [University of Oxford](#)



High-dimensional PDF of a flow undergoing turbulent mixing revealed by TN simulation.
Credit: Nikita Gourianov et al

Researchers at the University of Oxford have pioneered a new approach to simulate turbulent systems, based on probabilities. The findings [appear](#) in the journal *Science Advances*.

Predicting the dynamics of turbulent fluid flows has long been a central goal for scientists and engineers. Yet, even with modern computing technology, direct and accurate simulation of all but the simplest turbulent flows remains impossible.

This is due to turbulence being characterized by eddies and swirls of various shapes and sizes interacting in chaotic and unpredictable manners. For uses within engineering or weather-prediction, these fluctuations cannot be accurately simulated even by the most powerful supercomputers.

Working with colleagues at Hamburg, Pittsburgh and Cornell, the Oxford researchers reframed the problem in a manner that entirely avoids the need to directly resolve and simulate these turbulent fluctuations. Rather than simulating the troublesome fluctuations directly, they modeled these as random variables distributed according to a probability distribution function. Simulating such probability distributions enabled them to extract all meaningful quantities from the flow (for instance, lift and drag), without having to worry about the chaos of turbulent fluctuations.

Normally, simulating turbulence probability distributions requires solving high-dimensional Fokker-Planck equations—something that's not feasible using classical methods. To overcome this, the team applied a quantum-inspired computing technology developed at the University of Oxford. This method uses tensor networks to represent the turbulence probability distributions in a hyper-compressed format that enables their simulation.

In the study, the quantum-inspired computing algorithm running on a single CPU core required just a few hours to compute that which would take an equivalent classical algorithm several days to do on an entire supercomputer.

Yet this computational speedup is only the beginning. In the future, much greater gains are likely to be had by running the quantum-inspired tensor network algorithm on dedicated hardware, such as tensor processing units and fault-tolerant quantum chips.

According to the researchers, the approach not only questions the current limits of turbulence simulation, but also opens the door towards simulating other chaotic systems that can be described probabilistically.

Lead researcher Dr. Nikita Gourianov (Department of Physics, University of Oxford) said, "The demonstrated—and future—computational advantage not only opens up new, previously inaccessible areas of [turbulence](#) physics for scientific probing, but also beckons next-generation computational fluid dynamics codes. These could end up improving our weather forecasts, make our cars more aerodynamic, increase the efficiency of chemical industries, and more."

More information: Nikita Gourianov et al, Tensor networks enable the calculation of turbulence probability distributions, *Science Advances* (2025). [DOI: 10.1126/sciadv.ads5990](#)

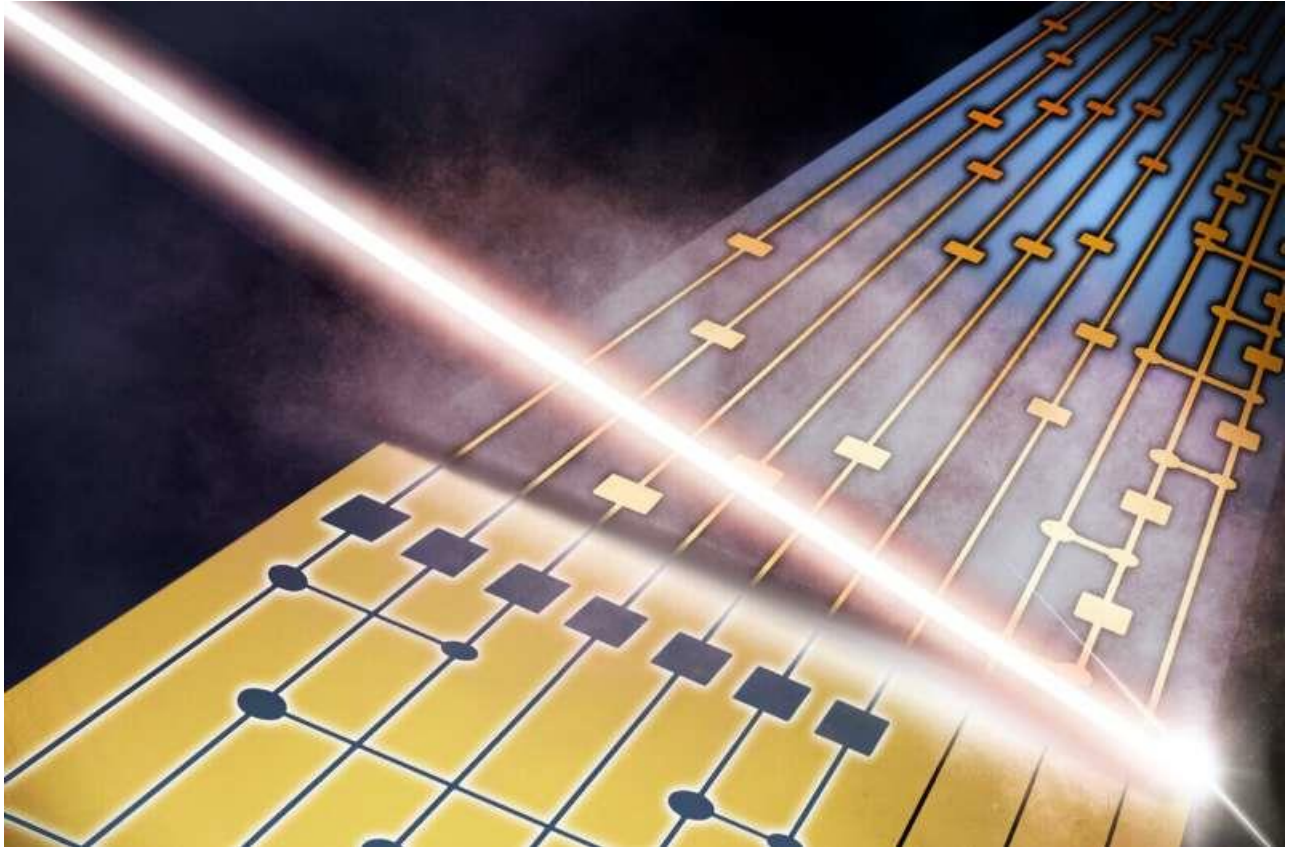
Journal information: [Science Advances](#)

Provided by [University of Oxford](#)

JANUARY 24, 2025

Quantum computer efficiently suppresses errors with two different correction codes

by [University of Innsbruck](#)



The Innsbruck quantum computer calculates with algorithms that switch back and forth between two different quantum error correction codes to realize error-corrected computing operations. Credit: Helene Hainzer

Computers also make mistakes. These are usually suppressed by technical measures or detected and corrected during the calculation. In quantum computers, this involves some effort, as no copy can be made of an unknown quantum state. This means that the state cannot be saved multiple times during the calculation and an error cannot be detected by comparing these copies.

Inspired by classical computer science, [quantum physics](#) has developed a different method in which the [quantum information](#) is distributed across several entangled [quantum bits](#) and stored redundantly in this way. How this is done is defined in so-called correction codes.

In 2022, a team led by Thomas Monz from the Department of Experimental Physics at the University of Innsbruck and Markus Müller from the Department of Quantum Information at RWTH Aachen and the Peter Grünberg Institute at Forschungszentrum Jülich in Germany implemented a universal set of operations on fault-tolerant quantum bits, demonstrating how an algorithm can be programmed on a quantum computer so that errors can be corrected efficiently.

However, different quantum error correction codes also come with different difficulties. A theorem states that no correction code can implement all the gate operations required for freely programmable computations with the logical quantum bits easily and protected against errors.

Quantum gates are realized with different correction codes

To circumvent this difficulty, Markus Müller's research group has established a method that allows the quantum computer to switch back and forth between two correction codes in an error-tolerant manner.

The findings were published in the journal *Nature Physics*.

"In this way, the quantum computer can switch to the second code whenever a logic gate that is difficult to realize appears in the first code. This makes it easier to implement all the gates required for computing," explains Friederike Butt, a doctoral student in Markus Müller's research group.

She developed the quantum circuits on which the experiment is based and implemented them in close collaboration with Thomas Monz's research group in Innsbruck.

"Together, we have succeeded for the first time in realizing a universal set of [quantum gates](#) on an ion trap quantum computer using two combined quantum error correction codes," says Ph.D. student Ivan Pogorelov from the Innsbruck research group.

"This result is based on our many years of good collaboration with Markus Müller's team," says Thomas Monz, who knows the [theoretical physicist](#) from his doctoral studies at the University of Innsbruck.

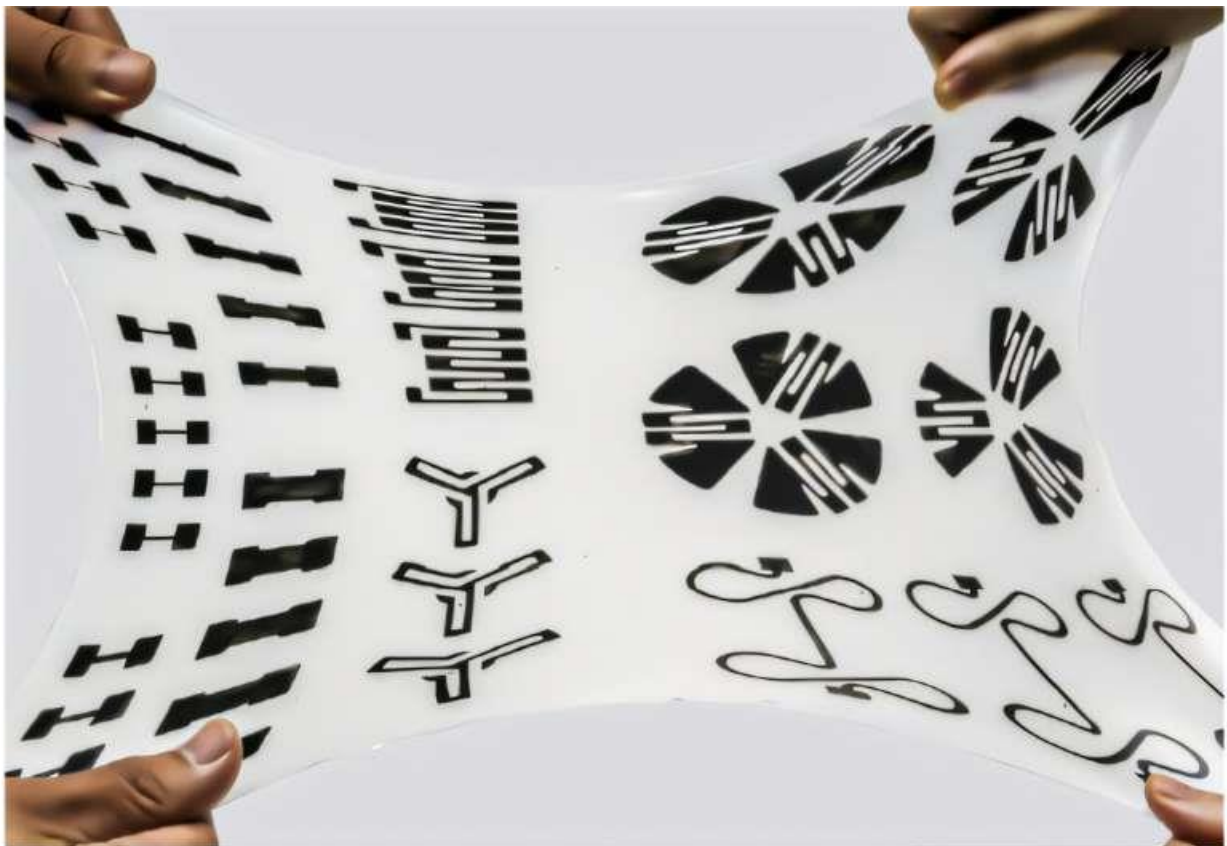
More information: Experimental fault-tolerant code switching, *Nature Physics* (2025). [DOI: 10.1038/s41567-024-02727-2](#). On *arXiv*: [DOI: 10.48550/arxiv.2403.13732](#)

Journal information: [Nature Physics](#) , [arXiv](#)

JANUARY 23, 2025 **FEATURE**

A new method to fabricate soft electronics via particle engulfment printing

by Ingrid Fadelli , Tech Xplore



Soft sensors engulfed on A4-size elastomer. Credit: Rongzhou Lin.

The electronics industry has been rapidly advancing over the past few decades, leading to the development of countless devices of different sizes and shapes, which are designed for a variety of applications.

These include stretchable electronics, which are sensors and other devices that can be used to create smart watches, fitness trackers, bio-medical sensors to monitor specific health conditions and [soft robots](#).

Flexible electronics are typically made using soft polymers, elastic materials comprised of long molecular chains that can undergo significant deformation without breaking. To broaden their functions or boost their performance, these polymers are often combined with

microscale or [nanoscale particles](#) that have specific optoelectronic or [magnetic properties](#), also known as functional particles.

Most existing approaches to introducing functional particles in polymers work by dispersing the particles into liquid molecules that bond with other molecules to form a polymer before the material is solidified. Yet many of these strategies are only applicable to some polymer-particle combinations or are difficult to implement on a large scale.

Prof. John Ho's research group at the National University of Singapore and Prof. Yong Lin Kong's group at Rice University recently introduced a new method for fabricating soft electronics, which is outlined in a [paper](#) in *Nature Electronics*.

The first author of this paper is Dr. Rongzhou Lin, who was a post-doctoral scholar at the time and is now a faculty member at the South China University of Technology.

The new approach developed by the researchers leverages a soft matter physics phenomenon called 'particle engulfment' to embed particles into a soft polymer. Particle engulfment is a spontaneous process that occurs when the so-called elastocapillary length of a polymer's matrix surpasses the characteristic length of particles.

"Elastocapillary length is the length scale at which the surface stress becomes important over bulk elastic stresses," Prof. Yong Lin Kong, the co-corresponding author of the paper, told Tech Xplore.

"For example, when a particle with a size smaller than the elastocapillary length (e.g., a very soft substrate) is left on the surface, the surface stress of the substrate can dominate, so much so that it becomes energetically favorable for the particle to be 'subsumed' by the solid substrate itself.

"This phenomenon itself is not new and was already studied by others within the soft matter physics community, including as part of a beautiful work by Prof. Eric Dufresne at Cornell University. However, prior work studied particle engulfment with a few particles and it had so far not been employed to fabricate electronics."

While they were trying to create an effective soft strain sensor, the researchers found that existing approaches to disperse CNT particles into polymer solutions did not reliably produce the [conductive polymers](#) needed for high-performance stretchable sensors. Yet accidentally, they discovered the advantages of leveraging particle engulfment to create these conductive polymers for [stretchable electronics](#).

"Conventional methods for creating strain sensors using carbon nanotube (CNT) typically involve dispersing CNTs into a polymer precursor with the use of solvents," Rongzhou Lin, first author of the paper, told Tech Xplore.

"However, we encountered challenges in producing conductive composites using this approach. Unexpectedly, we discovered that applying rubber CNTs onto cured silicone resulted in the easy formation of conductive composites."

When they investigated this phenomenon further, the researchers found that nanomaterials can spontaneously embed themselves into the polymer matrix via the particle engulfment phenomenon. They then integrated this approach with a printing set-up, using a stencil mask to control the exposed areas, which was found to successfully incorporate a broad range of functional particles into soft polymers.

To demonstrate the potential of their proposed method, the team used it to create elastic electronics with multiple layers incorporating various materials. The devices they fabricated could be suitable for different real-world applications, as they were found to possess wireless sensing, communication and power transfer capabilities.

"To the best of our knowledge, this was the first successful use of particle engulfment to make soft electronics," Lin said.

In addition to demonstrating the possibility of using particle engulfment to develop system-level electronics with tissue-like properties, this study also opens up new possibilities for soft matter physics research. Future studies could leverage the methods employed by the team to further study the physics underpinning particle engulfment.

"As this is the first experimental study on the engulfment of high concentrations of particles, our experimental data can potentially unravel new physical insights that have not been previously explored," Kong added.

"Our intriguing observations open new questions in soft matter physics, such as multi-layer engulfment of particles that could inspire future applications."

As the new strategy devised by the researchers is both scalable and reliable, it could soon also be employed by other teams, contributing to the further advancement of the electronics industry.

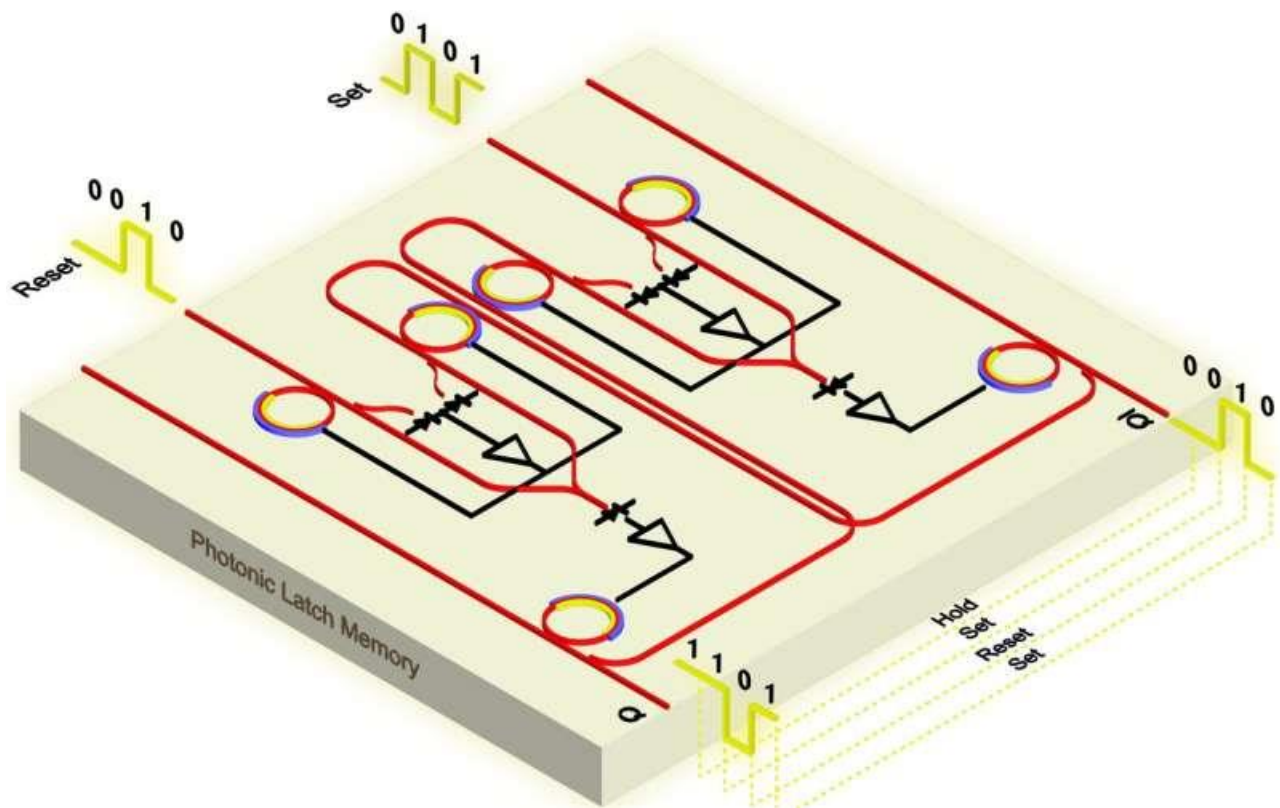
In the future, it could be used to fabricate a broader range of electronics, including electronic skins for robots and stretchable sensors for wearable devices.

More information: Rongzhou Lin et al, Soft electronics based on particle engulfment printing, *Nature Electronics* (2025). DOI: [10.1038/s41928-024-01291-0](https://doi.org/10.1038/s41928-024-01291-0).

Journal information: [Nature Electronics](#)

Scalable optical memory unit poised to improve processing speed and efficiency

by [Optica](#)



This new type of optical memory unit, called a programmable photonic latch, is fast and scalable. It could offer a high-speed silicon photonics solution for volatile memory. Credit: Farshid Ashtiani, Nokia Bell Labs

Researchers have developed a new type of optical memory called a programmable photonic latch that is fast and scalable. This fundamental memory unit enables temporary data storage in optical processing systems, offering a high-speed solution for volatile memory using silicon photonics.

The new integrated photonic latch is modeled after a set-reset latch, a basic memory device used in [electronic devices](#) to store a single bit by switching between set (1) and reset (0) states based on inputs.

"While [optical communications](#) and computing have seen significant progress over the past decades, [data storage](#) has been predominantly implemented using electronic memory," said the study's author Farshid Ashtiani from Nokia Bell Labs.

"Having a fast optical memory that can be used with optical processing systems, as well as other [optical systems](#) used in communications or sensing, would make them more efficient in terms of energy and throughput."

In a paper, titled "Programmable photonic latch memory" in *Optics Express*, the [researchers describe](#) a proof-of-concept experiment in which they demonstrated the photonic latch using a programmable silicon photonic platform. Features such as optical set and reset, complementary outputs, scalability and compatibility with wavelength division multiplexing (WDM) make this approach promising for faster and more efficient optical processing systems.

"Large language models like ChatGPT rely on massive amounts of simple mathematical operations, such as multiplication and addition, performed iteratively to learn and generate answers," said Ashtiani.

"Our [memory technology](#) could store and retrieve data for such systems at high speeds, enabling much faster operations. While a commercial optical computer is still a distant goal, our high-speed optical memory technology is a step toward this future."

Advancing integrated optical memory

Optical technologies have been instrumental in advancing communication systems, from long-haul data transmission and data center connectivity to emerging technologies like optical interconnects and computing. However, data storage remains predominantly electronic due to its scalability, compactness and cost-effectiveness.

This presents challenges for optical processing systems because transferring optical data to electronic memory—and back—increases energy consumption and introduces latency.

Although there has been extensive research in the area of optical memory, most implementations rely on bulky, costly and energy-intensive setups or specialized materials that are not typically offered in commercially available silicon photonic processes, leading to higher costs and lower yields.

To overcome these challenges, the researchers created an integrated programmable photonic latch based on optical universal logic gates using silicon photonic micro-ring modulators. These devices can be implemented in commercially available silicon photonic chip fabrication processes. They combined two optical universal logic gates to create an optical latch that can hold optical data.

Creating memory that is scalable and fast

Ashtiani says that one key advantage of the new system is its scalability. "Because each memory unit has an independent input light source, it is possible to have several memory units working independently without affecting each other through optical power loss propagation," he said.

"The memory units can also be co-designed with the existing silicon photonic systems and be built reliably and with very high yields."

Another advantage is the photonic memory unit's wavelength selectivity, which allows it to work seamlessly with WDM. This is because the unit's micro-ring modulators are designed to operate at specific wavelengths, enabling multi-bit data storage within a single memory unit.

Additionally, it enables fast memory response time, measured in tens of picoseconds, outpacing the clock speeds of advanced digital systems and supporting high-speed optical data storage.

To demonstrate this approach to optical memory before making dedicated chips, the researchers used a programmable photonic platform to implement the universal logic gates and the optical latch through experiments and realistic simulations.

The researchers tested the gates under different input scenarios. Even in the presence of random variations, the gates reliably generated the desired outputs. Similarly, the latch also performed all functions—set, reset, hold—accurately in the presence of input power variations.

Next, the researchers would like to pursue several research directions to make the new memory units more practical. This includes scaling the technology to a larger number of memory units and fabricating dedicated photonic memory chips.

This, combined with the WDM compatibility, would enable higher on-chip photonic memory density. They would also like to develop a way to use a single manufacturing process to integrate both the photonic memory circuit and the electronics needed to control it.

More information: Farshid Ashtiani, A programmable photonic latch memory, *Optics Express* (2024). DOI: [10.1364/OE.536535](https://doi.org/10.1364/OE.536535)

Journal information: [Optics Express](#)

Provided by [Optica](#)