



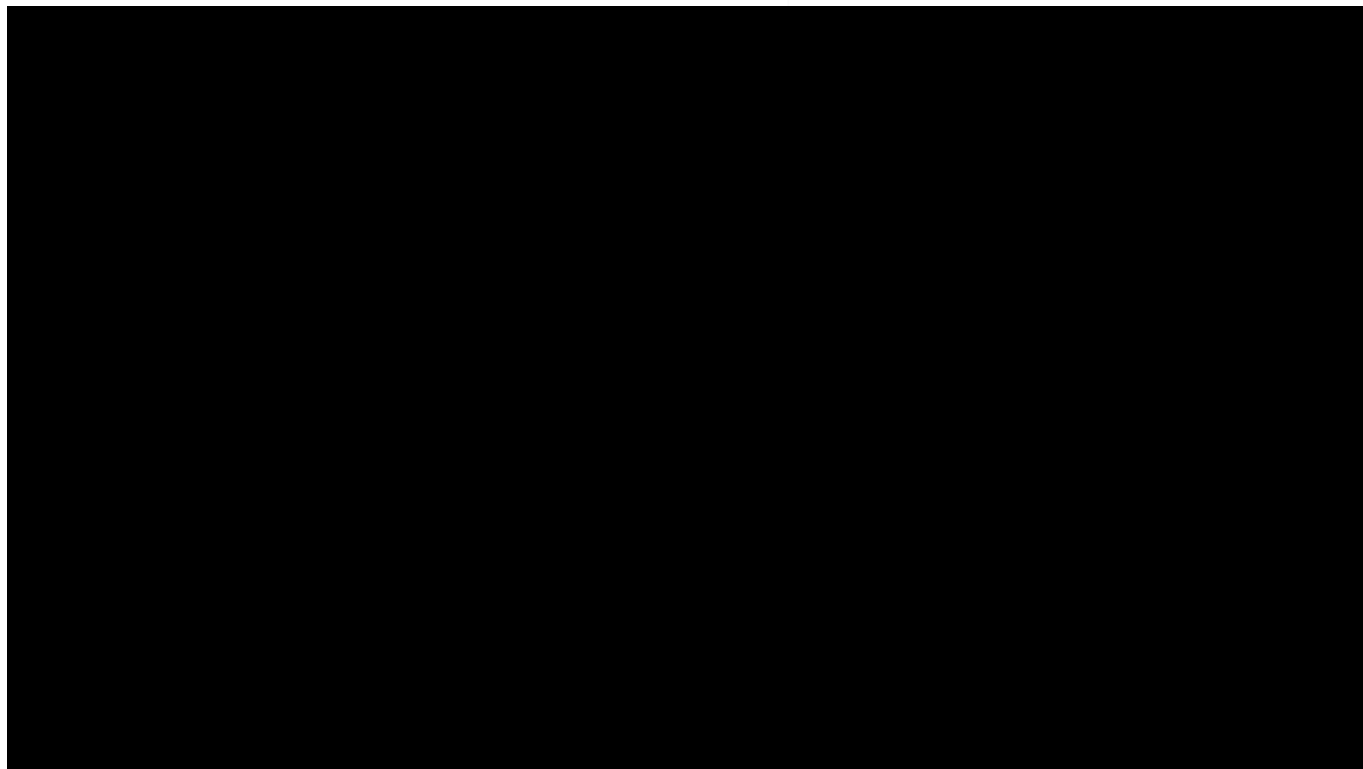
OPINION

Quantum computing has a hype problem

Quantum computing startups are all the rage, but it's unclear if they'll be able to produce anything of use in the near future.

By Sankar Das Sarma

March 28, 2022



MS TECH | GETTY

THIS IS YOUR FIRST COMPLIMENTARY STORY

Explore emerging technology with an MIT Technology Review subscription.

View offer

As a buzzword, quantum computing probably ranks only below AI in terms of hype. Large tech companies such as Alphabet, Amazon, and Microsoft now have substantial research and development efforts in quantum computing. A host of startups have sprung up as well, some boasting staggering valuations. IonQ, for example, was valued at \$2 billion when it went public in October through a special-purpose acquisition company. Much of this commercial activity has happened with baffling speed over the past three years.

I am as pro-quantum-computing as one can be: I've published more than 100 technical papers on the subject, and many of my PhD students and postdoctoral fellows are now well-known quantum computing practitioners all over the world. But I'm disturbed by some of the quantum computing hype I see these days, particularly when it comes to claims about how it will be commercialized.

Established applications for quantum computers do exist. The best known is Peter Shor's 1994 theoretical demonstration that a quantum computer can solve the hard problem of finding the prime factors of large numbers exponentially faster than all classical schemes. Prime factorization is at the heart of breaking the universally used RSA-based cryptography, so Shor's factorization scheme immediately attracted the attention of national governments everywhere, leading to considerable quantum-computing research funding.

The only problem? Actually making a quantum computer that could do it. That depends on implementing an idea pioneered by Shor and others called quantum-error correction, a process to compensate for the fact that quantum states disappear quickly because of environmental noise (a phenomenon called "decoherence"). In 1994, scientists thought that such error correction would be easy because physics allows it. But in practice, it is extremely difficult.

used for computation—so-called logical qubits; the rest would be needed for error correction, compensating for decoherence.

Related Story

This new startup has built a record-breaking 256-qubit quantum computer

QuEra Computing, launched by physicists at Harvard and MIT, is trying a different quantum approach to tackle impossibly hard computational tasks.

The qubit systems we have today are a tremendous scientific achievement, but they take us no closer to having a quantum computer that can solve a problem that anybody cares about. It is akin to trying to make today's best smartphones using vacuum tubes from the early 1900s. You can put 100 tubes together and establish the principle that if you could somehow get 10 billion of them to work together in a coherent, seamless manner, you could achieve all kinds of miracles. What, however, is missing is the breakthrough of integrated circuits and CPUs leading to smartphones—it took 60 years of very difficult engineering to go from the invention of transistors to the smartphone with no new physics involved in the process.

There are in fact ideas, and I played some role in developing the theories for these ideas, for bypassing quantum error correction by using far-more-stable qubits, in an approach called topological quantum computing. Microsoft is working on this approach. But it turns out that developing topological quantum-computing hardware is also a huge challenge. It is unclear whether extensive quantum error correction or topological quantum computing (or something else, like a hybrid between the two) will be the eventual winner.

Physicists are smart as we all know (disclosure: I am a physicist), and some physicists are also very good at coming up with substantive-sounding acronyms that stick. The great difficulty in getting rid of decoherence has led to the impressive acronym NISQ for “noisy intermediate scale quantum” computer—for the idea that small collections of noisy physical qubits could do something useful and better than a classical computer can. I am not sure what this object is: How noisy? How many qubits? Why is this a computer? What worthy problems can such a NISQ machine solve?

A recent laboratory experiment at Google has observed some predicted aspects of quantum dynamics (dubbed “time crystals”) using 20 noisy superconducting qubits. The experiment was an impressive showcase of electronic control techniques, but it showed no computing

Using NISQ is surely an excellent new fundamental research idea—it could help physics research in fundamental areas such as quantum dynamics. But despite a constant drumbeat of NISQ hype coming from various quantum computing startups, the commercialization potential is far from clear. I have seen vague claims about how NISQ could be used for fast optimization or even for AI training. I am no expert in optimization or AI, but I have asked the experts, and they are equally mystified. I have asked researchers involved in various startups how NISQ would optimize any hard task involving real-world applications, and I interpret their convoluted answers as basically saying that since we do not quite understand how classical machine learning and AI really work, it is possible that NISQ could do this even faster. Maybe, but this is hoping for the best, not technology.


There are proposals to use small-scale quantum computers for drug design, as a way to quickly calculate molecular structure, which is a baffling application given that quantum chemistry is a minuscule part of the whole process. Equally perplexing are claims that near-term quantum computers will help in finance. No technical papers convincingly demonstrate that small quantum computers, let alone NISQ machines, can lead to significant optimization in algorithmic trading or risk evaluation or arbitrage or hedging or targeting and prediction or asset trading or risk profiling. This however has not prevented several investment banks from jumping on the quantum-computing bandwagon.

A real quantum computer will have applications unimaginable today, just as when the first transistor was made in 1947, nobody could foresee how it would ultimately lead to smartphones and laptops. I am all for hope and am a big believer in quantum computing as a potentially disruptive technology, but to claim that it would start producing millions of dollars of profit for real companies selling services or products in the near future is very perplexing to me. How?

Quantum computing is indeed one of the most important developments not only in physics, but in all of science. But “entanglement” and “superposition” are not magic wands that we can shake and expect to transform technology in the near future. Quantum mechanics is indeed weird and counterintuitive, but that by itself does not guarantee revenue and profit.

A decade and more ago, I was often asked when I thought a real quantum computer would be built. (It is interesting that I no longer face this question as quantum-computing hype has apparently convinced people that these systems already exist or are just around the corner). My unequivocal answer was always that I do not know. Predicting the future of technology is impossible—it happens when it happens. One might try to draw an analogy with the past. It

back in the early 16th century, with Leonardo da Vinci's flying machine? I do not know. Neither does anybody else.

Sankar Das Sarma is the director of the Condensed Matter Theory Center at the University of Maryland, College Park. 
by Sankar Das Sarma

DEEP DIVE

COMPUTING

What's next for the world's fastest supercomputers

Scientists have begun running experiments on Frontier, the world's first official exascale machine, while facilities worldwide build other machines to join the ranks.

By Sophia Chen

The power of green computing

Sustainable computing practices have the power to both infuse operational efficiencies and greatly reduce energy consumption, says Jen Huffstetler, chief product sustainability officer at Intel.

**By
MIT Technology Review Insights**

AI-powered 6G networks will reshape digital interactions

The convergence of AI and communication technologies will create 6G networks that make hyperconnectivity and immersive experiences an everyday reality for consumers.

By
MIT Technology Review Insights

How this Turing Award–winning researcher became a legendary academic advisor

Theoretical computer scientist Manuel Blum has guided generations of graduate students into fruitful careers in the field.

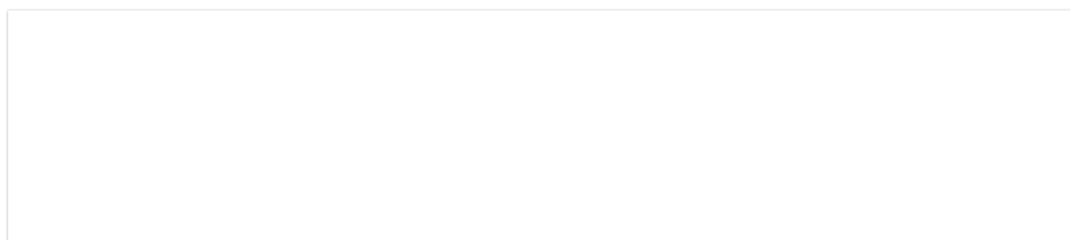
By Sheon Han

STAY CONNECTED

Illustration by Rose Wong

Get the latest updates from MIT Technology Review

Discover special offers, top stories, upcoming events, and more.



Privacy Policy

Founded at the Massachusetts Institute of Technology in 1899, MIT Technology Review is a world-renowned, independent media company whose insight, analysis, reviews, interviews and live events explain the newest technologies and their commercial, social and political impact.

READ ABOUT OUR HISTORY

Advertise with MIT Technology Review

Elevate your brand to the forefront of conversation around emerging technologies that are radically transforming business. From event sponsorships to custom content to visually arresting video storytelling, advertising with MIT Technology Review creates opportunities for your brand to resonate with an unmatched audience of technology and business elite.

ADVERTISE WITH US

[About us](#)

[Careers](#)

[Custom content](#)

[Advertise with us](#)

[International Editions](#)

[My subscription](#)

[Editorial guidelines](#)

[Privacy policy](#)

[Terms of Service](#)

[Write for us](#)

[Contact us](#)



© 2023 MIT Technology Review