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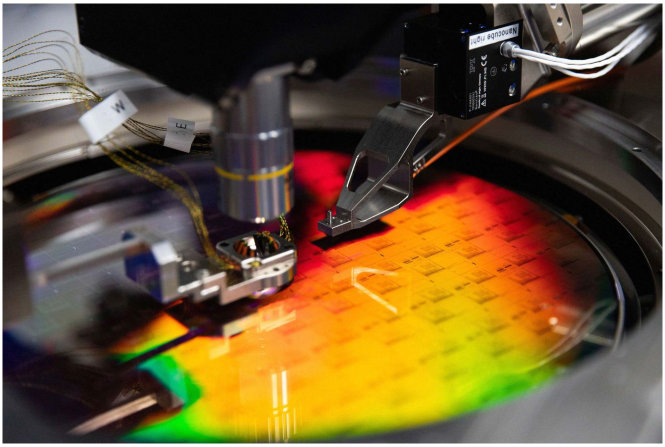
Quantum Computing Startup Raises $215 Million for Faster Device

- PsiQuantum's photon-based model is still years away, but the company says it'll be more powerful than Google's or IBM's.

By Ashlee Vance



▲ A PsiQuantum silicon wafer at the company's lab in Palo Alto. SOURCE: PSIQUANTUM

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The technology industry has spent decades trying to puzzle out the basis of a quantum computer. Such a machine, powered not by the simple on/off choreography of conventional transistors but by the ethereal forces of quantum mechanics, would allow for calculations on a scale inconceivable with today's fastest processors. Engineers, mathematicians, and scientists talking about the theoretical applications of quantum computers make them sound like magic wands—capable of unlocking huge troves of secrets about our physical world and advancing civilization in dramatic ways. If only we could build one.

PsiQuantum, a 5-year-old startup based in Palo Alto, Calif., says it's well on its way to creating a commercial quantum machine, the boldest claim to date among a legion of hopefuls in the field. It has raised $215 million to build a computer with 1 million qubits, or quantum bits,

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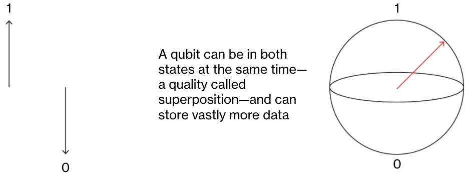
within “a handful of years,” co-founder and Chief Executive Officer Jeremy O’Brien tells *Bloomberg Businessweek*. While the qubit figure will mean little to people outside the industry, it’s considered the breakthrough point for making a true, general-purpose quantum computer that would be broadly useful to businesses. As such, PsiQuantum’s machine would mark a major leap forward and deal a devastating blow to rival projects by the likes of Google, Honeywell, IBM, and a sea of startups and university labs. “If they are really able to pull this off, it immediately distinguishes them and puts them in a completely different field so far ahead of the competition,” says Peter Rohde, a Future Fellow at the Centre for Quantum Software & Information at the University of Technology Sydney. “This strikes me as incredibly exciting.”

▲ PsiQuantum CEO Jeremy O’Brien. PHOTOGRAPHER: CARLOS CHAVARRIA FOR BLOOMBERG BUSINESSWEEK

The “if” from Rohde reflects the challenges of quantum computing and, partly, the secrecy that has surrounded PsiQuantum’s work. O’Brien’s interview with *Bloomberg Businessweek* is his first detailed discussion of the company’s technology since its founding in 2015. The CEO and his co-founders (Terry Rudolph, Mark Thompson, and Pete Shadbolt) are Australian and British academics turned industrialists. Over the past five years, they’ve hired more than 100 people to help them try to develop what’s known as a silicon photonic quantum computer—essentially, a computer that runs on light.

Today’s computer chips each contain billions of tiny transistors that flip between on and off states to form binary digits, or bits, strings of ones and zeros that the computers can translate into electronic information and instructions. The idea behind a quantum computer is that it will run on qubits, which are similar to standard bits but far more flexible. Based on principles of quantum mechanics, each qubit can be a one and a zero simultaneously. Picture a piece of string fixed between two points. Pluck the string just right, and it makes a wave where it appears to be up and down at the same time.

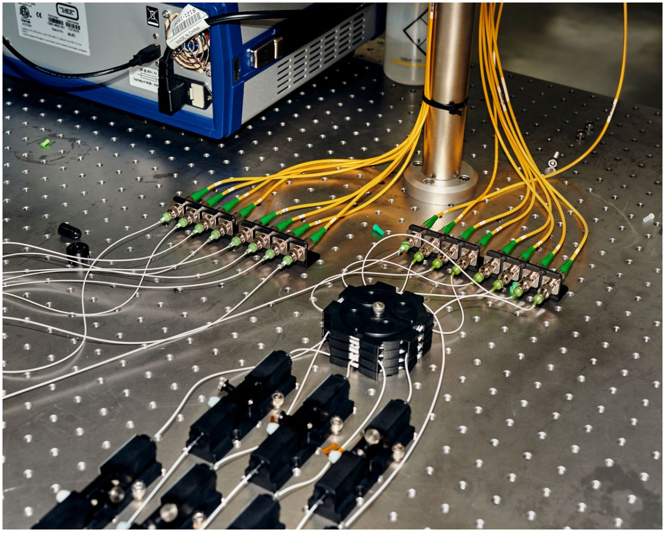

Qubits

A bit in today's computers can be in a state of either one (on) or zero (off)

A qubit can be in both states at the same time—a quality called superposition—and can store vastly more data

These properties, in theory, allow quantum computers to achieve a quantum speedup, which grows exponentially as more qubits are added to the system. The ramifications are mind-blowing. "By the time you get to 80 qubits, you are in a place where the qubits are storing more information than the total number of atoms in the entire universe," says Samir Kumar, general manager of Microsoft Corp.'s venture capital arm, which has invested in PsiQuantum. Practically speaking, this means large calculations that would take decades or centuries to complete using even modern supercomputers can be performed in minutes on a quantum machine. The belief is this will lead to stunning breakthroughs in chemistry, biology, and other scientific fields.

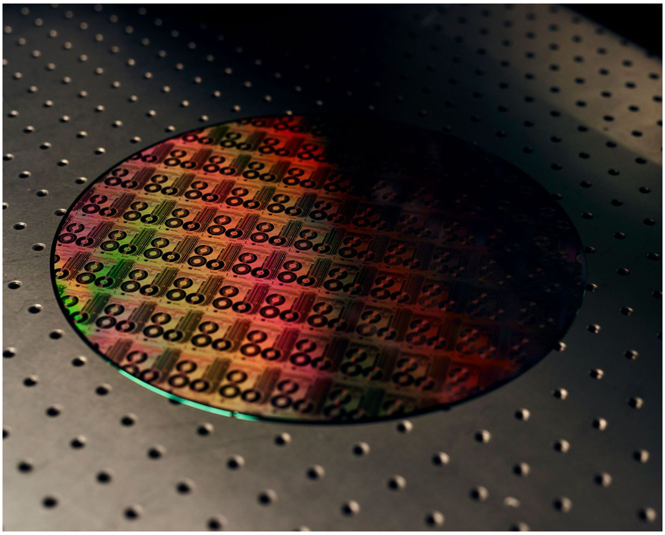
Researchers have discovered numerous techniques for creating qubits, but PsiQuantum is making them with photons, or single particles of light. These photons are sent down pathways placed on a silicon chip. Tiny, partially reflective mirrors bounce the photons into a state of entanglement where more quantum forces can be applied to bind qubits in ways that amplify their forces. Then a sensor measures the photons, and some further steps allow the PsiQuantum team to produce and read a calculation.



▲ Optical fibers on a test bench at PsiQuantum's lab. PHOTOGRAPHER: CARLOS CHAVARRIA FOR BLOOMBERG BUSINESSWEEK

The techniques PsiQuantum is pursuing were considered virtually impossible to pull off for a time. Among other obstacles, scientists thought a machine based on photonics would have to be incredibly large. "As we began working on this architecture, it appeared that our machine would have to be the size of the Sierra Nevada mountain range," O'Brien says. After a series of research advances, however, his team has set to work building its first computer, which it expects will be the size of an office conference room. GlobalFoundries, one of the world's top chipmakers, has already started producing early versions of PsiQuantum's chips using its standard manufacturing facilities. (This marks a significant contrast with other quantum experiments, which rely on exotic materials and custom manufacturing.) Now it's up to O'Brien's engineers to create quantum variants of the networking, software, and the other components needed to make a functioning computer. "We're going to be building them as fast as you can," O'Brien says.

The leading quantum contenders to this point have crafted lab-bound machines that top out in the dozens of qubits. Last year, Google showed that its 54-qubit machine needed only three minutes to perform a calculation that would take a traditional supercomputer 10,000 years. While impressive, the feat was considered of limited use because Google's machine was built to perform well on that single calculation rather than a broad set of jobs. It and rival devices have also lacked sophisticated error correction technology, which is deemed crucial to ensuring that calculations derived from a mass of entangled qubits are trustworthy.



▲ A PsiQuantum wafer with dozens of quantum chips. PHOTOGRAPHER: CARLOS CHAVARRIA FOR BLOOMBERG BUSINESSWEEK

PsiQuantum's big claim is that its technology will be able to string together 1 million qubits and distill out 100 to 300 error-corrected or "useful" qubits from that total. O'Brien and PsiQuantum's backers question whether Google can ever reach similar qubit totals with its technology. "It is like climbing a tree to get to the moon," says Peter Barrett, a general partner at Playground Global, which invested in PsiQuantum. A Google spokesperson says the company typically does not comment on rivals' work.

Of course, PsiQuantum has a ways to go, too. Until it has a completed computer, the company can't run calculations to compare against Google or anyone else. It's also declining to publish academic papers that can be reviewed for their merits or to let outsiders evaluate its technology. "I'm a little hesitant to trust anybody until I see some sort of refereed publication or detailed specs," says Jonathan Dowling, a quantum computing expert who co-directs the Hearne Institute for Theoretical Physics. "I love Jeremy, but he's a good salesman, too."

O'Brien acknowledges that PsiQuantum's secrecy breeds skepticism, but he remains supremely confident in the company's technology. "I don't want to sound arrogant here, but I really don't care what people's criticisms are," he says. "I just could care less whether someone's got 5, 10, 50, or 100 qubits. If you need a million, tell me how close you are in time and money to that. That's what we've done."

What's clear for the moment is that O'Brien and his co-founders have attracted a ton of cash and a world-class team. Rudolph, the company's chief architect, happens to be the illegitimate grandson of famed quantum theorist and Nobel Prize-winning cat hater Erwin Schrödinger. Besides Microsoft and Playground, PsiQuantum's investors include Atomico, Founders Fund, Redpoint Ventures, and BlackRock Advisors. "There are still R&D problems to be solved," says Siraj Khaliq, a partner at Atomico. "But they have solutions and then backup plans for most of them."

O'Brien says he's already looking ahead to the problems that quantum computing may be able to solve, from calculating which catalyst for carbon sequestration can best slow climate change to mapping more efficient ways to fertilize crops and feed an ever-growing population. "I think it is fair to say that we are going to look back on the pre-quantum computing world and wonder how we survived," he says, "never mind sustained 10 billion people with our primitive, caveman tools."

BOTTOM LINE - PsiQuantum's well-pedigreed team has raised $215 million from big names for its photonic quantum computing model, but a working device is still likely years away.

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