

Breaking through the quantum noise barrier

ASU research could help unlock the promise of practical quantum computing

By Kelly deVos, ASU News
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Quantum computing has spent years existing in the space between promise and practicality.

The machines exist. [Tech giants are building them](#). Researchers have shown that, for certain problems, quantum computers could one day dramatically outperform today's fastest supercomputers.

The obstacle isn't that the computers don't work. It's that they're extraordinarily fragile.

Unlike traditional computers, which store information as ones and zeros, quantum computers perform calculations using quantum bits, or qubits. Those qubits are so sensitive that tiny interactions with their surroundings, such as imperfections in the hardware or subtle environmental disturbances, can introduce random errors into a calculation.

Computer scientists call this quantum noise, and it remains one of the biggest barriers to making quantum computers practical.

[Baoyu Zhou's](#) work embraces the fact that quantum computers are imperfect. Instead of waiting for better hardware, he's building mathematical tools that help researchers make better use of the hardware they already have.

Zhou is an assistant professor of industrial engineering in the [School of Computing and Augmented Intelligence](#), part of the [Ira A. Fulton Schools of Engineering](#) at Arizona State University.

With a new three-year grant from the U.S. [National Science Foundation](#), he'll work with [Xiu Yang](#), an associate professor at Lehigh University, on optimization algorithms designed specifically for today's generation of quantum computers. The collaborative project will create scalable mathematical methods that continue performing reliably even when quantum hardware produces uncertain or noisy results.

"The question is how we design more efficient, robust algorithms that can work despite the noise in today's quantum hardware," Zhou says. "I'm pretty optimistic that quantum computers will eventually become powerful enough for everyday use, and I want to help make that future possible."

Finding a signal in the noise

Many of today's most promising quantum computing techniques work through trial and error, repeatedly testing possible solutions until they find the best one. But quantum noise makes that process unreliable. As problems become larger and more complex, it becomes increasingly difficult to tell whether the computer has found a genuinely better solution or whether random errors have simply distorted the results.

Zhou is developing mathematical methods that can make those decisions more reliable. Instead of assuming every calculation is perfect, his algorithms account for uncertainty from the start, allowing quantum computers to tackle larger, more complicated problems with greater confidence.

His team will evaluate those methods across a range of quantum computing applications, with potential implications for fields including artificial intelligence, molecular design and biotechnology.

The project fits naturally within Zhou's broader research agenda.

He describes himself first and foremost as an optimization researcher. Whether the challenge involves machine learning, engineering systems or quantum computing, his focus is developing mathematical algorithms capable of solving increasingly complex challenges efficiently.

His interest in quantum computing began during his doctoral studies at Lehigh University, where he regularly attended lectures from a neighboring quantum optimization research group. Although quantum computing wasn't the focus of Zhou's dissertation, the field captured his imagination and eventually became part of his long-term research vision.

Today, the NSF award will help support Zhou's doctoral students while expanding interdisciplinary collaborations in an area poised for rapid growth.

The next quantum leap

The project also begins as Arizona is making an ambitious push to establish itself as a national center for quantum technology.

Earlier this year, Phoenix launched its [Quantum Strategy initiative](#), appointing former NSF Director and ASU University Professor of Technology and Innovation [Sethuraman Panchanathan](#) to lead efforts to position the region as a hub for quantum computing, communication and sensing.

"Baoyu's work is exactly the kind of foundational research that will help establish Phoenix as a global leader in quantum technologies," Panchanathan says. "ASU and our partner institutions are cultivating the talent and ideas that will drive new discoveries, prepare a highly skilled workforce and accelerate the emergence of new industries."

As companies race to build more powerful quantum hardware, researchers like Zhou are working on an equally essential piece of the puzzle: the mathematical foundations that will allow those machines to solve meaningful problems under real-world conditions.

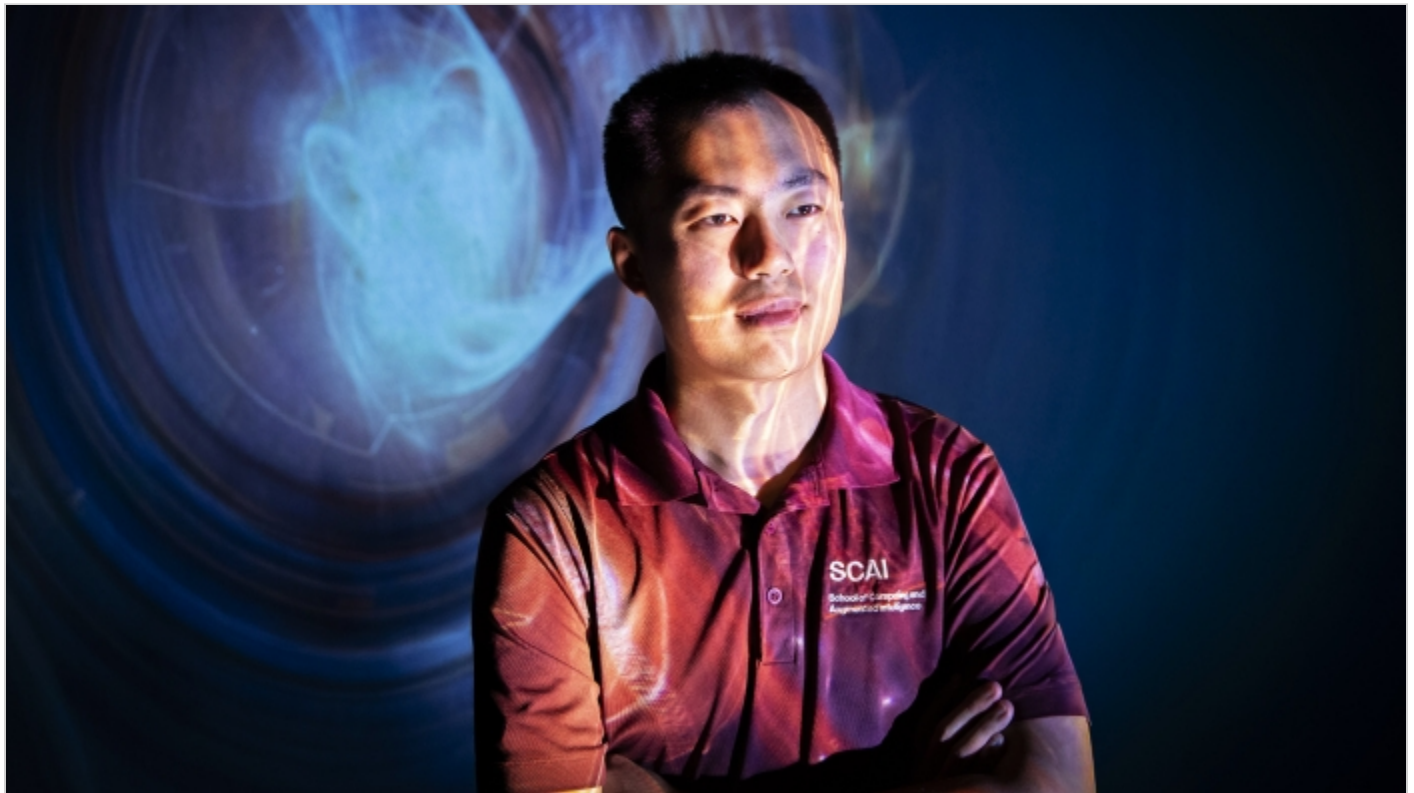
After three years, Zhou hopes his team will have developed scalable optimization algorithms that make today's imperfect quantum computers more capable, while training graduate students and releasing open-source software to help accelerate research across the field.

Quantum computers may someday revolutionize everything from drug discovery to cybersecurity. But before they can transform the world, they first must learn how to produce reliable answers in an unreliable environment.

That's the challenge Zhou is tackling by developing the mathematical tools that help today's imperfect quantum computers reach tomorrow's potential.

This story originally appeared on [ASU News](#).

Main image



Baoyu Zhou and an illustration of a quantum particle. Zhou is an assistant professor of industrial engineering in the School of Computing and Augmented Intelligence, part of the Ira A. Fulton Schools of Engineering at Arizona State University, who has received funding from the National Science Foundation for new research to address a problem known as quantum noise. Photo by Erika Gronek/ASU