Columbia leads effort to develop a quantum simulator

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Columbia is one of 11 institutions nationwide to receive a Phase One National Science Foundation Convergence Accelerator award for quantum technology. The program is designed to foster multidisciplinary, cross-sector research in emerging areas of critical societal importance. Credit: NSF

Quantum technologies—simulators and computers specifically—have the potential to revolutionize the 21st century, from improved national defense systems to drug discovery to more powerful sensors and

communication networks.

But the field still needs to make major advances before quantum computing can surpass existing tools to process information and live up to its promise.

A multidisciplinary research team led by Columbia University is in a position to bring quantum technology out of the lab into real-world applications.

The team has received a $1 million National Science Foundation (NSF) Convergence Accelerator award to build a quantum simulator, a device that can solve problems that are difficult to simulate on classical computers. The project includes physicists, engineers, computer scientists, mathematicians, and educators from academia, national labs, and industry.

"This funding will enable us to develop the concept for a quantum simulator that can help tackle real-world challenges," said Sebastian Will, assistant professor of physics at Columbia and principal investigator on the project. "For this we brought a diverse team together that includes experts in atomic physics, photonics, electronics, and software, as well as future users of the platform."

The National Science Foundation launched its Convergence Accelerator program, a new structure unique for NSF and the federal government, in 2019 to help quickly transition research and discovery aligning with NSF's "Big Ideas" into practice. In 2020, the NSF continues to invest in two transformative research areas of national importance: quantum technology and artificial intelligence.

Columbia is one of 11 institutions nationwide to receive a Phase One Convergence Accelerator award for quantum technology. These awards

support the National Quantum Initiative Act passed in 2018 to accelerate the development of quantum science and information technology applications. The U.S. Congress has authorized up to $1.2 billion of research funding for quantum information science, including computing.

The hope of building a quantum computer with the potential to resolve seemingly intractable problems across many different industries and applications relies on controlling microscopic quantum systems with higher and higher precision in order to put them to work for computing tasks.

With this grant, the Columbia team will develop hardware and software concepts to build a versatile quantum simulator based on ordered arrays of atoms. The group will store quantum information in individual atoms and program them to perform quantum simulations. Besides developing the device, the plan is to make it accessible to a broad user base via cloud-computing.

Over the next nine months, the 2020 cohort Convergence Accelerator teams will work to develop their initial concept, identify new team members, and participate in a curriculum focusing on design, team science, pitch preparation, and presentation coaching. After developing a prototype, the teams will participate in a pitch competition and proposal evaluation. Teams selected for phase two will be eligible for additional funding: up to $5 million over 24 months.

By the end of phase two, teams are expected to deliver solutions that impact societal needs at scale.

"The quantum technology and AI-driven data and model-sharing topics were chosen based on community input and identified federal research and development priorities," said Douglas Maughan, head of the NSF Convergence Accelerator program. "This is the program's second cohort,

and we are excited for these teams to use convergence research and innovation-centric fundamentals to accelerate solutions that have a positive societal impact."

The simulator project team includes collaborators from Columbia University, principal investigator Sebastian Will, co-principal investigators Alex Gaeta and Nanfang Yu, and others; Brookhaven National Lab, co-principal investigators Layla Hormozi and Gabriella Carini, and others; City University of New York; Flatiron Institute; and industry partners from Atom Computing, QuEra, IBM, and Bloomberg.

Provided by Columbia University