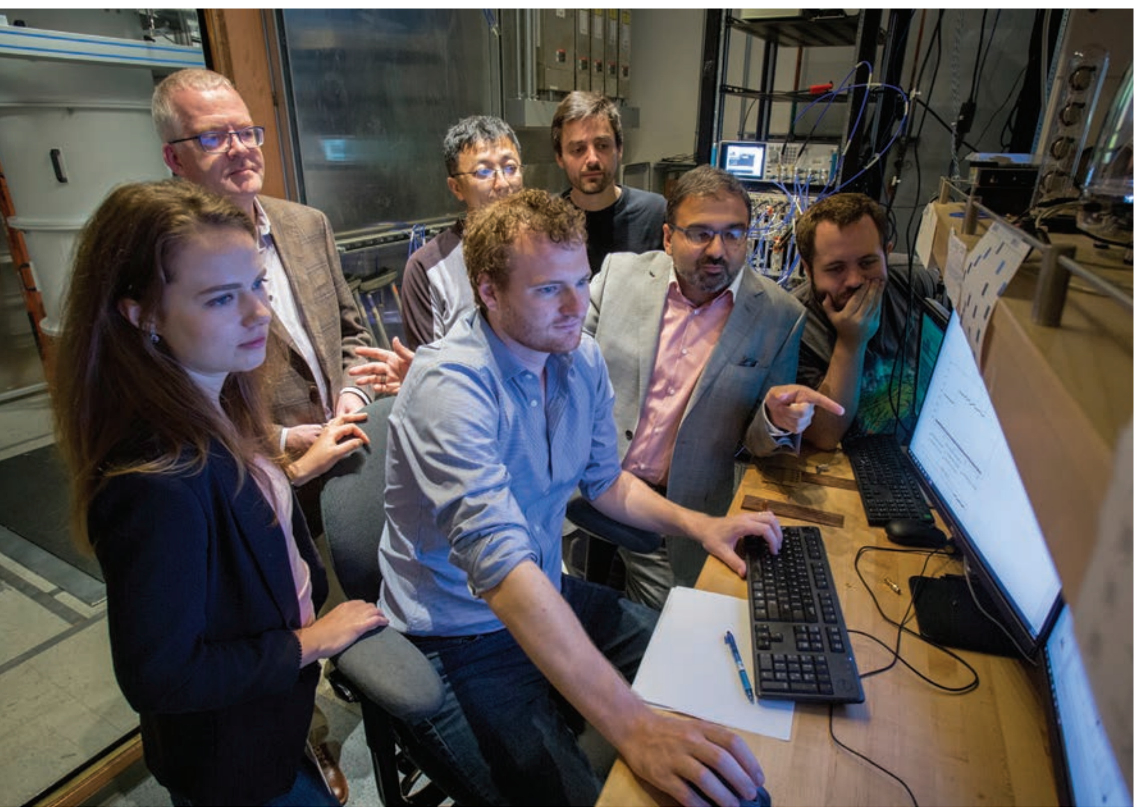
The Quantum Systems Accelerator (QSA) is a new research center that aims to harness the advantages of quantum information science for the benefit of scientific discovery and society at large. It's a network of world-class research facilities, academic leaders, and industry partners working together to speed development and commercialization of quantum information systems, including quantum computers.

Quantum Systems Accelerator

Advancing quantum information science through collaboration



QSA is led by Lawrence Berkeley National Laboratory (Berkeley Lab), co-led by Sandia National Laboratories, and directed by **Irfan Siddiqi**, Berkeley Physics professor and faculty scientist at Berkeley Lab. "The global race is on," Siddiqi says, "to build quantum systems that fuel discovery and make possible the next generation of information technology."

QSA's core team of researchers includes dozens of leading scientists at 15 partner institutions who have pioneered many of today's quantum capabilities. QSA actively joins with industry and international programs to accelerate the pace of research and development and shepherd promising technologies from the lab to the factory.

"An overall goal is to foster US leadership in quantum information science and to develop the algorithms, quantum devices, and engineering solutions needed to deliver quantum advantage in scientific applications," says **Chris Spitzer**, Berkeley Physics alum and QSA's Associate Director for Operations.

EMPHASIZING COLLABORATION

"QSA brings together research on all parts of a quantum computing system," Spitzer continues, "from the materials it's built of, to the architecture of its quantum processors, to its algorithms and simulations. We want to maximize performance in the near term and then chart a pathway to the powerful quantum computing systems that we know are possible but don't yet know how to achieve."

"Too often," he adds, "different aspects of quantum research proceed in isolation from each other. People working on algorithms don't necessarily think about what a physical hardware system looks like or how it operates. People looking at processor design don't always think about the properties of the materials or potential sources of noise. The exciting thing about QSA is that it brings together groups who don't usually talk to each other. This process catalyzes new and unique ideas and identifies critical areas for development of practical quantum systems."

DEVELOPING A DIVERSE QUANTUM WORKFORCE

QSA and its broad network of partners are also preparing the future quantum workforce – from scientists, engineers, and technicians to nontechnical professionals and even new careers not yet imagined. Among these efforts is development of coursework and training materials for K-12 and community college students, graduate students, and postdocs. Apprenticeships are being created to open up opportunities for anyone interested in quantum science, including underrepresented populations.

"We're looking at the entire pipeline," Spitzer notes, "including resources aimed for working professionals who want to take skills developed in other fields and apply them to quantum science."

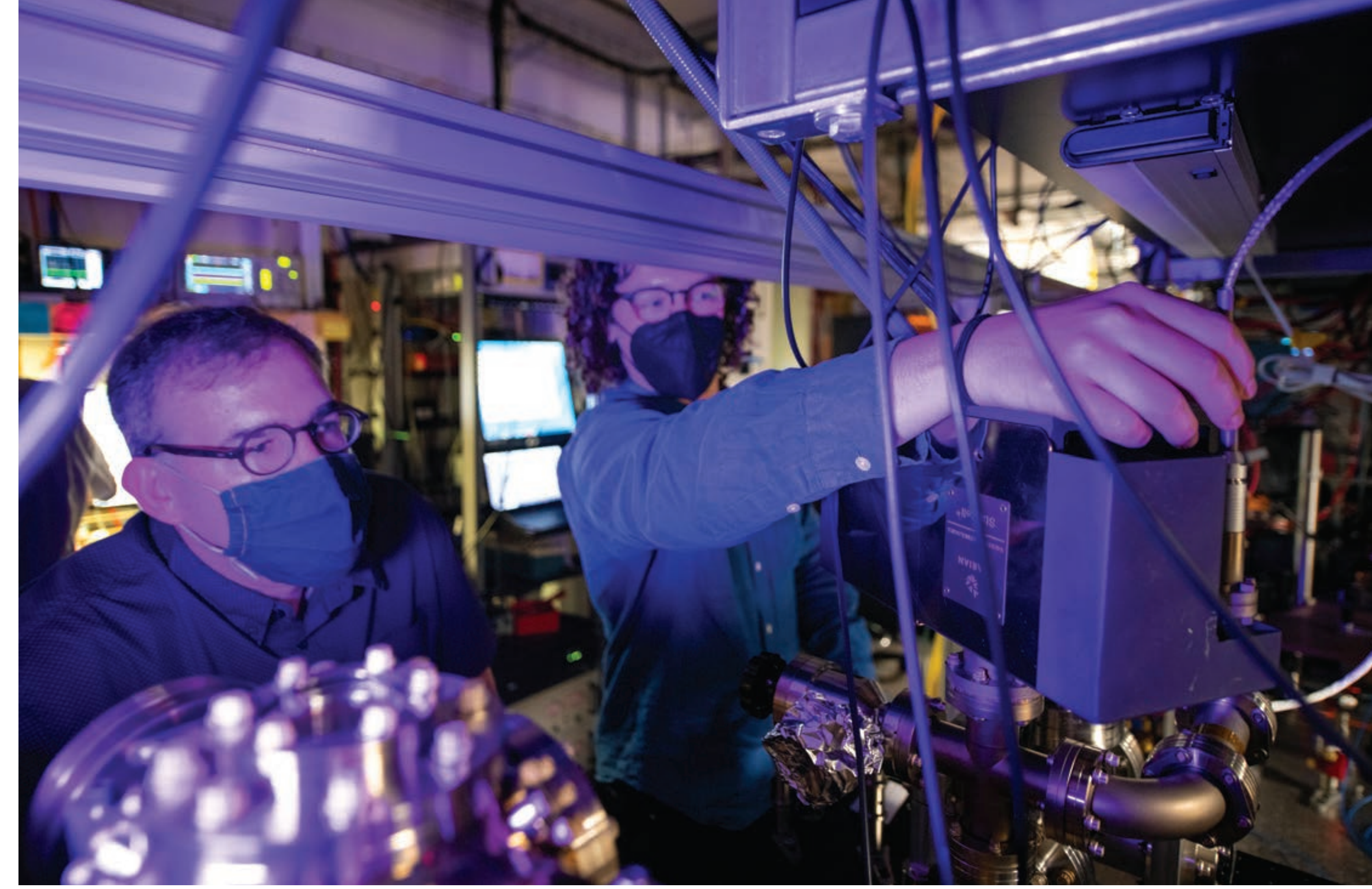


PHOTO: KEEGAN HOUSER

Professor Dan Stamper-Kurn (left) in the E8 Lab lab with post doc Scott Eustice.

Opposite: Professor Irfan Siddiqi (second from right) and team at the Quantum Systems Accelerator. (Photo taken prior to March 2020)

THE ONE STOP QUANTUM SHOP

A new web portal, the One Stop Quantum Shop, facilitates communication between QSA and the wider quantum information community. It serves as a central repository for technical data, publications, and software. It provides access to collaborative project information and offers connections to experts in quantum information. And it links the growing quantum community to resources on training, internships, events, and educational outreach programs. "It's a networking hub where anyone can go to learn what's needed to get involved in quantum computing," Spitzer notes.

QSA is one of five US Department of Energy (DOE) National Quantum Information Science Research Centers announced in August 2020. Planned funding by the DOE's Office of Science totals $115 million over five years.

Programmable Quantum Systems

The Quantum Systems Accelerator supports cutting-edge research across the country and around the globe. A number of Berkeley Physics faculty are among the scientists whose research includes QSA projects. Professor **Dan Stamper-Kurn** is one example. His Ultracold Atomic Physics group at Berkeley studies novel phases of matter governed by quantum mechanics.

Stamper-Kurn's research group uses beams of laser light to cool single atoms to near absolute zero, suspend them in a vacuum, and manipulate their interactions. "We create neutral-atom quantum systems that are complex and behave in highly controlled and significant ways," Stamper-Kurn says. "This is a very different kind of platform for computing. An atom-based quantum computer might turn out to be an ultra-high vacuum chamber supported by lasers that are turned on and off to orchestrate the system's operation."

Until recently, research on ultra-cold atoms has focused on two families of elements. Alkalis, on the left side of the periodic table, have simple, spherical atomic structures that are relatively easy to control with lasers, but limited in the kinds of interactions that would be needed for quantum computing. Lanthanides, at the bottom of the periodic table, are highly complex, with interesting and useful interactions, but extremely difficult to control.

"We decided to look for something intermediate," Stamper-Kurn reports, "and we have discovered that transition metals, elements from the middle of the periodic table, might be amenable to the kinds of tricks we use to cool atoms. No one had noticed this before."

Transition metals look especially promising because interactions between a light beam and an atom depend strongly on the polarization of the light and energy state of the atom. "That's an essential manipulation tool," Stamper-Kurn says. QSA supports Stamper-Kurn's efforts to bring the family of transition metals into quantum science and, ultimately, to develop a programmable quantum information system.

The group's initial experiments are focused on titanium. "We found that the energy state you need to start with for laser cooling is not the lowest energy state of the titanium atom," Stamper-Kurn notes. "But once the atom has been prepared, all the standard laser cooling methods should work. We see this pattern repeated in a number of other transition metals, roughly doubling the number of elements you can work with in these experiments. That's super exciting. It will make a really big difference."