

How the San Francisco Bay Area is Leading the Quantum Revolution

Jeffrey Welser and Sean Randolph – November 13, 2020

San Francisco Bay Area universities, research institutes, and companies were pivotal in launching the modern computer industry and remain at the heart of the global technological revolution. The next great advance is at our doorstep: quantum computing. This is a global race that it is imperative the U.S. lead.

Not a replacement for conventional computers, quantum computers have the potential to vastly outperform today's computers in solving for particular problems. By harnessing quantum bits (or "qubits"), they will accelerate research on technologies ranging from solar cells and batteries to pharmaceuticals and new materials, speed the development of artificial intelligence, and deepen our understanding of physics and the universe.

But performing quantum computing at scale isn't easy — we're still years away from fault-tolerant systems. The challenge lies in what makes quantum states unique: where in ordinary physics matter exists in a state of 0 or 1 (the basis of digital computing today), in quantum physics matter can exist in multiple states between 0 and 1. The instability of that state makes it difficult to manage and measure. These "errors" or "faults" pose a major scientific challenge that governments and scientists around the world are racing to address.

In the last few years the United States — through the White House Office of Science and Technology Policy (OSTP), the National Science Foundation (NSF) and the Department of Energy (DOE) — has stepped up its game. The National Quantum Initiative Act, passed and signed into law in December 2018, called for the creation of research centers across the country to accelerate foundational quantum R&D. The Bay Area Science and Innovation Consortium (BASIC), a partnership of scientific leaders representing research universities, federal and independent laboratories, and corporate

laboratories in the Bay Area, was a proponent and urged that its implementation be prioritized.

Major steps were announced last summer and Bay Area scientific research institutions, many of them BASIC members, are among the leaders. In July \$75 million in grants over five years was awarded by the NSF and OSTP for three new Quantum Leap Challenge Institutes, one of which — the NSF Quantum Leap Challenge Institute for Present and Future Quantum Computing — is led by UC Berkeley.

In August OSTP, the NSF and DOE announced over \$1 billion in awards for the establishment of 12 new artificial intelligence (AI) and Quantum Information Science (QIS) research institutes across the country. With funding distributed over five years, the centers will serve as multi-disciplinary and multi-institutional hubs for research and workforce development in these critical emerging technologies.

Two AI research institutes include Bay Area members: the USDA-NIFA AI Institute for Next Generation Food Systems (led by UC Davis and including UC Berkeley), and the NSF AI Institute for Student and AI Teaming (which includes UC Berkeley and UC Santa Cruz.)

In the field of quantum, \$625 million was awarded by the DOE to QIS Centers at Argonne, Brookhaven, Fermi, Oak Ridge and Lawrence Berkeley National Laboratory (Berkeley Lab). Of that, \$115 million will be directed to the Quantum Systems Accelerator (QSA), a consortium of 15 research institutions led by Berkeley Lab that also includes Sandia National Laboratory and UC Berkeley. Research will support DOE's critical missions and expedite the ability of industry to develop commercial products. To cultivate a workforce of quantum scientists, engineers and technicians the center will partner with community colleges, workforce boards and industry to create curricula for educators and quantum science apprenticeships.

Q-Next, another of the five QIS Centers led by Argonne National Laboratory, counts the Bay Area's Stanford, SLAC National Accelerator Laboratory and IBM among its partners. IBM and Berkeley are partners in the Oak Ridge-led QIS Center, Quantum Science

Center (QSC); IBM also has a leading role in the QIS Center led by Brookhaven, the Co-Design Center for Quantum Advantage (C2QA).

The new quantum centers will accelerate US leadership in a vital emerging field. Like the digital computing revolution we're still experiencing, the quantum revolution will be propelled by scientific research organizations in the San Francisco Bay Area, one of the nation's key scientific centers. Working with research partners across the country, these companies and institutions are positioned to lead a new wave of scientific breakthroughs that will advance human knowledge and produce innovative business applications.

While 2020 has been a year of economic uncertainty, these national investments reconfirm the San Francisco Bay Area's scientific leadership and the important role the region will continue to play in the nation's technological development.

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