The Superconducting Quantum Materials and Systems Center at Fermilab

SQMS brings together world-class experts from 20 institutions to take on one of the biggest challenges in quantum science: extending the lifetimes of quantum states. Advances here will lead to Fermilab and its partners building and operating a revolutionary quantum computer and developing quantum sensors to aid the search for undiscovered particles.

The Superconducting Quantum Materials and Systems Center, or SQMS, led by Fermilab, brings together national laboratories, academia and industry to make revolutionary advances in quantum computing and sensing, including the building and deployment of a beyond-the-state-of-the-art quantum computer. The quantum devices developed at SQMS will have game-changing impacts in basic science and in our everyday lives.

Longer information lifetimes

The driving mission of SQMS is to overcome the biggest barrier to the construction of a quantum computer: the short lifetime of the information that lives in a qubit. Qubits are devices that hold quantum information, analogs of the classical computer bit. Today's highest-performing qubits maintain information for milliseconds—not long enough for a viable quantum computer. SQMS researchers aim to design and fabricate qubits whose coherence times are thousands of times longer.

The specially designed qubits will leverage components called superconducting cavities, which were developed for particle accelerators. Fermilab-developed cavities have achieved coherence times of several seconds. By integrating cutting-edge, industry-designed and -fabricated computer chips into these cavities, SQMS collaborators expect to produce qubits with the longest coherence times ever demonstrated.

Instrumentally quantum

One of the ambitious goals of SQMS is to build and deploy a revolutionary quantum computer. Center researchers are also working to develop ultrasensitive quantum sensors, which aid physicists in searches for undiscovered particles and could lead to the discovery of the nature of dark matter.

A well-rounded partnership

SQMS is a National Quantum Initiative Center, one of only five in the United States. A partnership of 20 institutions, it unites forefront achievements and world-class expertise in superconductivity, materials, computational and quantum science and technology. Fermilab is the host institution for SQMS, whose partners include Ames Laboratory, the Italian National Institute for Nuclear Physics, NASA Ames Research Center, the National Institute of Standards and Technology, Northwestern University and Rigetti Computing.

At the SQMS Center at Fermilab, scientists will leverage superconducting cavities to extend qubit coherence times. Photo: Fermilab

Quantum for all

Work at SQMS will have an impact far beyond quantum science and fundamental physics. Quantum innovation could transform fields such as biology, medicine and national security. By drawing on the research strengths of its partners, SQMS is advancing quantum science for the benefit of all.