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Superconducting Quantum Materials and Systems (SQMS) - a new DOE National Quantum Information Science Research Center

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In this colloquium we will describe the mission, goals and the partnership strengths of the new SQMS Center. SQMS brings the power of DOE laboratories, together with industry, academia and other federal entities, to achieve transformational advances in the major cross-cutting challenge of understanding and eliminating the decoherence mechanisms in superconducting 2D and 3D devices, with the final goal of enabling construction and deployment of superior quantum systems for computing and sensing. SQMS combines the strengths of an array of experts and world-class facilities towards these common goals. Materials science experts will work in understanding and mitigating the key limiting mechanisms of coherence in the quantum regime. Coherence time is the limit on how long a qubit can retain its quantum state before that state is ruined by noise. It is critical to advancing quantum computing, sensing and communication. SQMS is leading the way in extending coherence time of superconducting quantum systems thanks to world-class materials science and through the development of superconducting quantum cavities integrated with industry-designed and -fabricated computer chips. Leveraging new understanding from the materials development, quantum device and quantum computing researchers will pursue device integration and quantum controls development for 2-D and 3-D superconducting architectures. One of the ambitious goals of SQMS is to build and deploy a beyond-state-of-the-art quantum computer based on superconducting technologies. Its unique high connectivity will provide unprecedented opportunity to explore novel quantum algorithms. SQMS researchers will ultimately build quantum computer prototypes based on 2-D and 3-D architectures, enabling new quantum simulation for science applications and will be made available to computing researchers via HEPCloud. High energy physics experts in the center will make use of the SQMS quantum technologies advancements for physics applications, improving current detection sensitivities by up to orders of magnitude, with consequent increased discovery potential. This will aid physicists in searches for undiscovered particles and could lead to the discovery of the nature of dark matter. Quantum communication experts in the center will deploy high-coherence devices with seconds of coherence time for microwave photons. This advance enables the development of quantum memories, a key component of long-range quantum communication systems. SQMS researchers plan to demonstrate microwave-to-microwave transfer of entangled states between 3-D quantum systems.