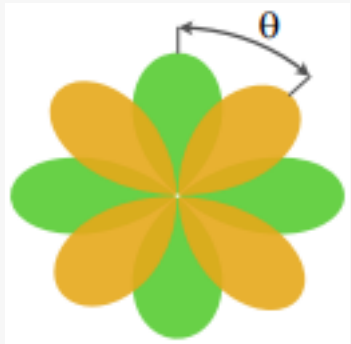
New Superconducting ‘Flowermon’ Qubit Boosts Stability of Quantum Information

Terra Quantum scientists and collaborators show that atomically thin crystals twisted together exponentially suppress environmental effects on qubit coherence



The flowermon superconducting qubit boosts the stability of quantum information

ST. GALLEN, SWITZERLAND, February 22, 2024 /EINPresswire.com/ -- Terra Quantum, a leading quantum technology company, today announced the joint publication of a research paper describing a new superconducting qubit expected to increase coherence times in quantum processors by orders of magnitude. The “flowermon” qubit represents a new class of superconducting devices that utilizes unconventional hybrid materials that could significantly improve the feasibility of scaling superconducting quantum processors.

“Superconducting Qubit Based on Twisted Cuprate Van der Waals Heterostructures” was published in Physical Review Letters and written by researchers from the Institute of Complex Systems of Italy’s National Research Council (ISC-CNR), Terra Quantum, the Max Plank Institute for Chemical Physics of Solids, the Leibniz Institute For Solid State and Materials Science Dresden, and the physics departments of the University of Naples and City College of City University of New York.

> “Simpler fabrication & tuning with longer coherence times make the flowermon a promising prototype for a new class of hybrid devices using the benefits of quantum materials & coherent quantum circuits.”
>
> *Markus Pflitsch, CEO of Terra Quantum*

The paper shows that the relative twist of the atomically thin superconducting crystals that form a Josephson junction to a 45-degree angle creates a special junction that maintains high coherence without the requirements of highly precise control of fabrication, tuning of the system, or circuit loops susceptible to environmental disturbances.

“Simpler fabrication and tuning with longer coherence times make the flowermon qubit a promising prototype for a new class of hybrid devices utilizing the benefits of quantum materials and coherent quantum circuits,” said Markus Pflitsch, CEO of Terra Quantum. “This step forward in materials science and quantum information advances the scalability of quantum devices toward meaningful applications.”

The paper describes the flowermon's exponential suppression of certain types of environmental noise and details schemes for manipulation and readout. Future research on the qubit may explore the practical implementation of these schemes to achieve the orders of magnitude improvement in coherence time at scale.

Coherence refers to the ability of a quantum system to maintain a superposition of quantum states over time. This is a crucial aspect of quantum information processing and a key factor in the development of useful quantum computers.

Josephson junctions, formed by two superconducting materials separated by a thin barrier, are the foundational building blocks of superconducting quantum computers. Other qubit types offering high coherence times often rely on multiple junctions in a flux loop, making them vulnerable to noise and fabrication imperfections.

"In contrast, the flowermon is a novel single-junction qubit that inherently protects against these drawbacks, including the exponential suppression of charge noise, providing a robust platform for future quantum devices," said Prof. Valentina Brosco, a researcher at ISC-CNR and the University of Rome and a coauthor of the paper.

The flowermon is created by twisting two flakes of Bi2212, a cuprate high temperature superconductor that preserves nearly perfect superconductivity, to a 45-degree angle to create a flower-like shape of the energy spectrum. This specific angle suppresses single electron pair tunneling across the junction, allowing two-pair tunneling to dominate the junction behavior.

While single-pair tunneling places the low energy qubit's states in a single well, two-pair tunneling spreads the qubit's states across two wells. This makes the qubit less sensitive to environmental effects, including charge noise and quasiparticle dissipation [1,2]. The reduction in sensitivity exponentially suppresses decoherence resulting from these types of noise.

"Our research builds on foundational superconducting technologies that were born by the discovery of superconductivity that dates back to 1911," said Prof. Vinokur. "With our new prototype for high-coherence hybrid superconducting quantum systems, we hope to set the foundation for the future of quantum devices based on high temperature superconductors. We look forward to witnessing our qubit's potential benefits to fabrication and highly coherent quantum systems."

The research was funded by the European Union (European Research Council), Deutsche Forschungsgemeischaft, US NSF Grant Awards, and Terra Quantum. The European Research

Council's cQEDscope project utilizes superconducting circuits to develop new quantum technologies and expand our understanding of superconductivity.

Notes

[1] Charge noise causes fluctuations in phase and energy levels of qubit states, resulting in decoherence. Variations in the charge environment can cause the qubit to transition between different energy states, resulting in the loss of quantum information.

[2] Quasiparticle-induced dissipation refers to energy loss caused by the presence of excitations that behave like particles. The excitations carry away energy and contribute to the loss of coherence.

About the Institute for Complex Systems – National Research Council of Italy

The Istituto dei Sistemi Complessi (Institute for Complex Systems) is part of the Consiglio Nazionale delle Ricerche (National Research Council). Its main research activities are the study of Classical and Quantum Complex Systems with particular emphasis on interdisciplinary Physics, Photonics, Superconductivity, Chemistry, Biology, Social Science and Economics.

About Terra Quantum

Terra Quantum Group is a leading quantum technology company based in Germany and Switzerland. It provides "Quantum as a Service (QaaS)" in three core areas, the first one being "Quantum Algorithms as a Service." Here, customers are provided access to an extensive library of algorithms, such as hybrid quantum optimization and hybrid quantum neural networks, which can be used for solving complex logistics problems or pattern recognition, among other things. Terra Quantum also develops new quantum algorithms for its customers or adapts existing algorithms to their specific needs. Secondly, through "Quantum Computing as a Service," Terra Quantum offers its customers access to its proprietary high-performance simulated quantum processing units (QPU), the quantum ecosystem's physical QPUs, while also developing native QPUs. The third division is "Quantum Security as a Service," through which Terra Quantum offers its unique solutions for secure quantum and post quantum communications worldwide.

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