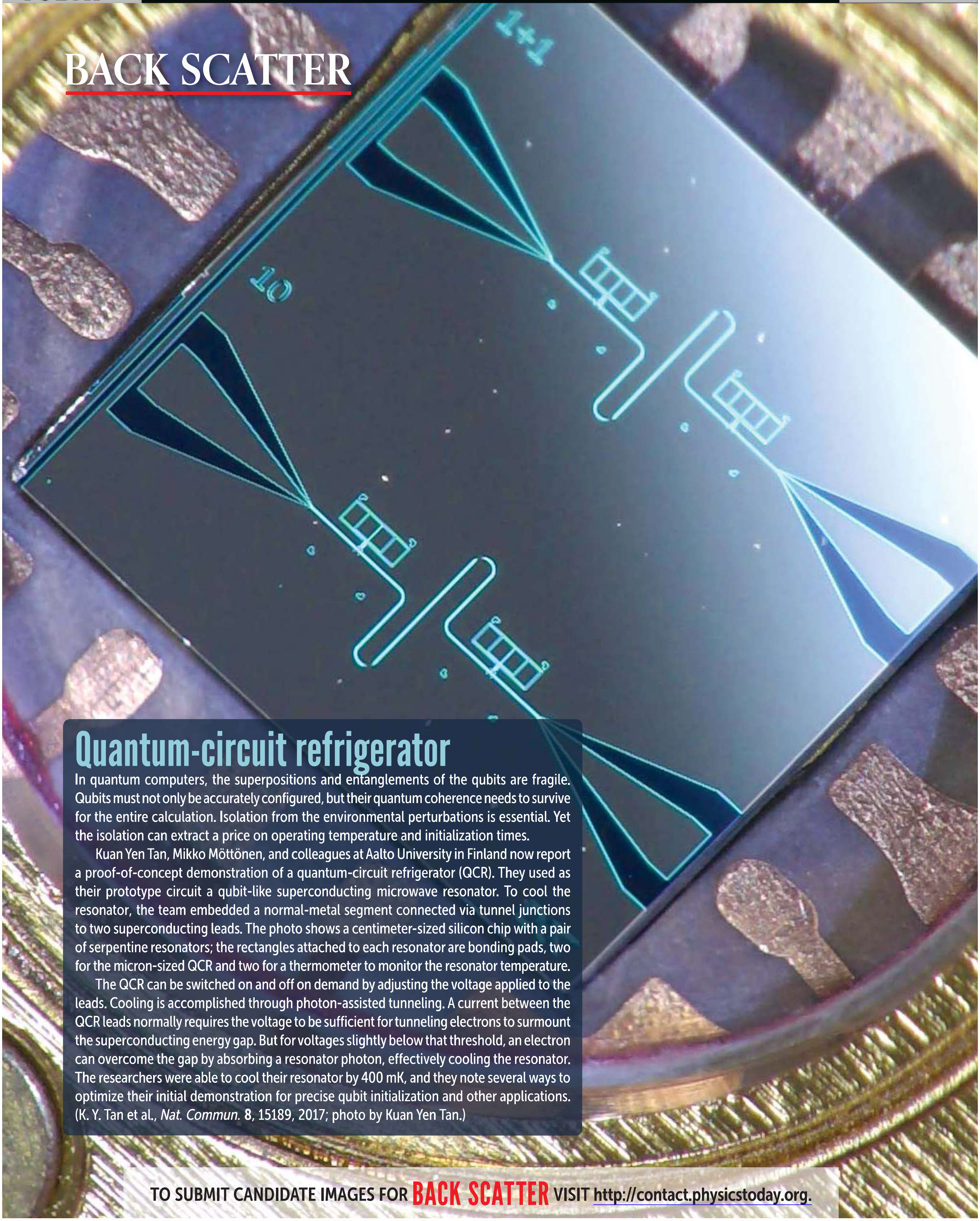
BACK SCATTER



Quantum-circuit refrigerator

In quantum computers, the superpositions and entanglements of the qubits are fragile. Qubits must not only be accurately configured, but their quantum coherence needs to survive for the entire calculation. Isolation from the environmental perturbations is essential. Yet the isolation can extract a price on operating temperature and initialization times.

Kuan Yen Tan, Mikko Möttönen, and colleagues at Aalto University in Finland now report a proof-of-concept demonstration of a quantum-circuit refrigerator (QCR). They used as their prototype circuit a qubit-like superconducting microwave resonator. To cool the resonator, the team embedded a normal-metal segment connected via tunnel junctions to two superconducting leads. The photo shows a centimeter-sized silicon chip with a pair of serpentine resonators; the rectangles attached to each resonator are bonding pads, two for the micron-sized QCR and two for a thermometer to monitor the resonator temperature.

The QCR can be switched on and off on demand by adjusting the voltage applied to the leads. Cooling is accomplished through photon-assisted tunneling. A current between the QCR leads normally requires the voltage to be sufficient for tunneling electrons to surmount the superconducting energy gap. But for voltages slightly below that threshold, an electron can overcome the gap by absorbing a resonator photon, effectively cooling the resonator. The researchers were able to cool their resonator by 400 mK, and they note several ways to optimize their initial demonstration for precise qubit initialization and other applications. (K. Y. Tan et al., *Nat. Commun.* **8**, 15189, 2017; photo by Kuan Yen Tan.)

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