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Detecting low-energy microwave photons emitted by superconducting qubits

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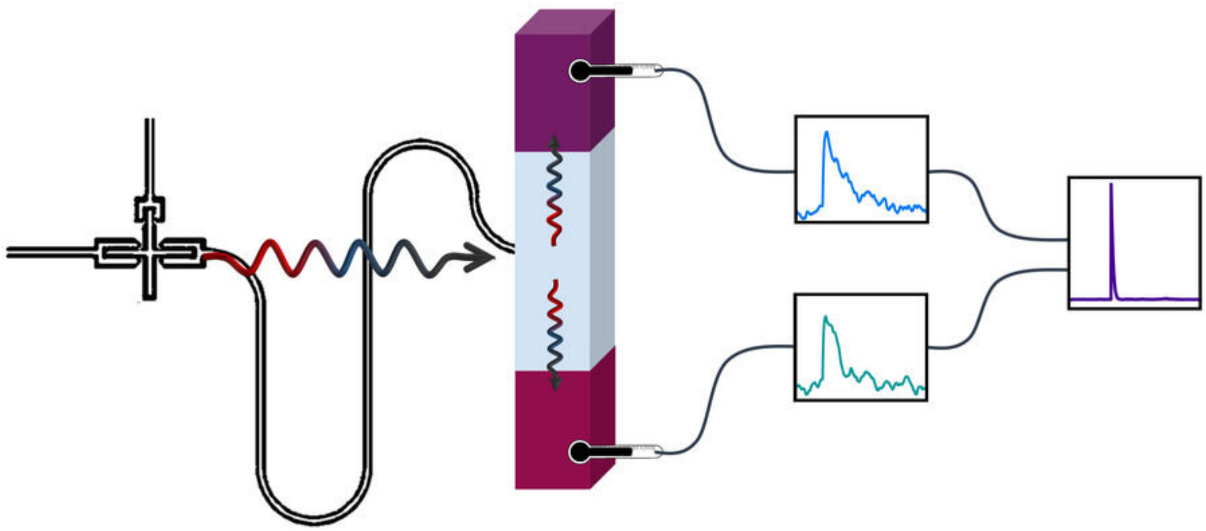

A low energy photon emitted by a qubit can potentially be detected by measuring its energy with two thermometers simultaneously. The two signals are combined into a cross-correlation measurement with superior sensitivity. Credit: Bayan Karimi

Professor Jukka Pekola and Doctoral Candidate Bayan Karimi from Aalto University propose a new approach to measure the energy of single microwave photons. These low energy quanta are emitted by artificial quantum systems such as superconducting qubits. Detecting them continuously has been challenging but would be useful in quantum information processing and other quantum technologies.

A photon is produced when a superconducting qubit transits between states, radiating energy into its environment. The researchers capture the tiny energy of this photon by transferring it into heat. The new technique relies on splitting the energy of a photon across two independent heat baths and making measurements using two uncoupled detectors at once. This would significantly enhance the signal-to-noise ratio, making it easier to detect an absorption event and its energy.

"In our proposed setup the energy of a qubit is large whereas its typical operating temperature is very low. This contrast opened an opportunity to solve the Schrödinger equation exactly for up to one million external oscillators forming the heat baths in the model describing this measurement," Pekola says.

Karimi adds that the "cross-correlation method can be used to measure extremely tiny temperature changes. It promises to detect energies several orders of magnitude smaller than in previously used methods."

The researchers explain that many fundamental questions remain open but this would be the first time the energy of a photon is split into two different thermal detectors and observed. The team in the Pico group at Aalto University is currently carrying out experiments based on this proposal. "Completing the experiment is extremely challenging, but success would be a dream come true," says Karimi.

The researchers introduced the extremely sensitive calorimeter two years ago, and Physics World listed the calorimeter as one of the quantum highlights of 2020.

More information: Jukka P. Pekola et al, Ultrasensitive Calorimetric Detection of Single Photons from Qubit Decay, *Physical Review X*

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