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One-way track for microwaves based on mechanical interference

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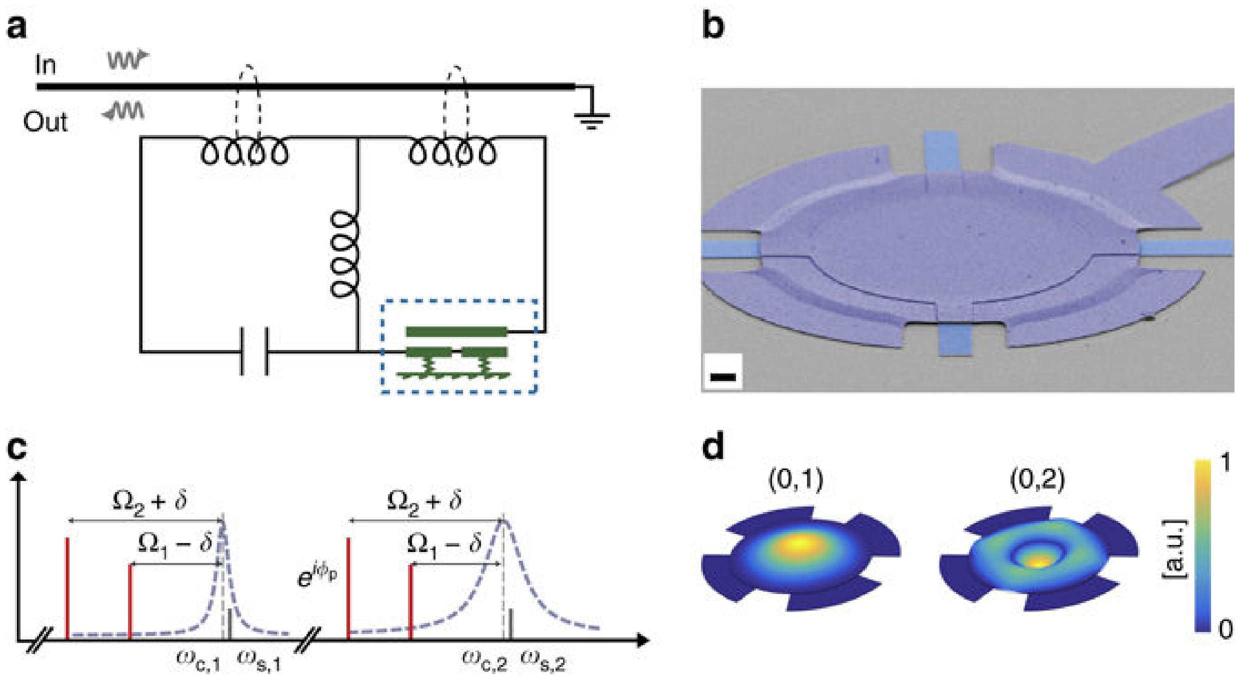

Implementation of a superconducting microwave circuit optomechanical device for nonreciprocity. Credit: *Nature Communications* (2017). DOI: 10.1038/s41467-017-00447-1

Devices that allow to route microwave signals are essential engineering tools. In particular, isolators, which let signals flow in one direction but block them in the other, are needed to protect sensitive equipment from harm. Now, scientists at EPFL and the University of Cambridge have demonstrated a new principle for developing such tools by harnessing the motion of microscopic drums. The study is published in *Nature Communications*.

The work was carried out by the lab of Tobias Kippenberg at EPFL, with theoretical support from the group of Andreas Nunnenkamp from the University of Cambridge. All samples were fabricated in the Center of MicroNanoTechnology (CMi) at EPFL. The demonstrated device consists of two resonant superconducting microwave circuits that are linked through a shared a capacitor. The top metallic membrane of this capacitor floats freely and supports mechanical oscillations, acting like a micro-drum, only 30 microns in diameter.

The vibrations modify the resonance frequencies of the microwave circuits and modulate the signals. Conversely, the electric field of signals exerts a force that changes the motion of the drum. This bi-directional interaction enables the conversion of signals from one microwave circuit to the other; the incoming signal is first converted to a vibrating motion, and then the motion itself is converted to a second signal emerging from the other circuit.

In the experiment, two different modes of oscillation of the micro-drum motion are used. These represent two paths for the microwave signals to be converted from one circuit to the other, resulting in interference, which, surprisingly, is not symmetrical in either direction of signal conversion.

The system can be tuned in such a way that positive interference occurs in one direction, while destructive interference occurs in the other. This realizes a microwave isolator that lets signals propagate only in a chosen direction, and the parameters can be modified on the fly, allowing dynamically reconfigurable use of the isolator, instantly changing its direction.

While commercial microwave isolators are common, they typically rely on magnetic ferrite materials and strong magnetic fields. This makes them impractical to use with superconducting qubits, which are becoming the leading candidates to use as building blocks for a quantum computer. But the lifetime of the fragile quantum states of the qubits is easily disturbed by magnetic fields, meaning that the ferrite isolators must be heavily shielded to prevent magnetic field leaking that can limit their use. For this reason, there has recently been substantial research activity to develop alternative technologies. The optomechanical isolator created at EPFL joins other prototypes—such as those using Josephson junctions—that might form a new platform to build such devices in the future.

More information: N. R. Bernier et al, Nonreciprocal reconfigurable microwave optomechanical circuit, *Nature Communications* (2017). DOI: 10.1038/s41467-017-00447-1

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