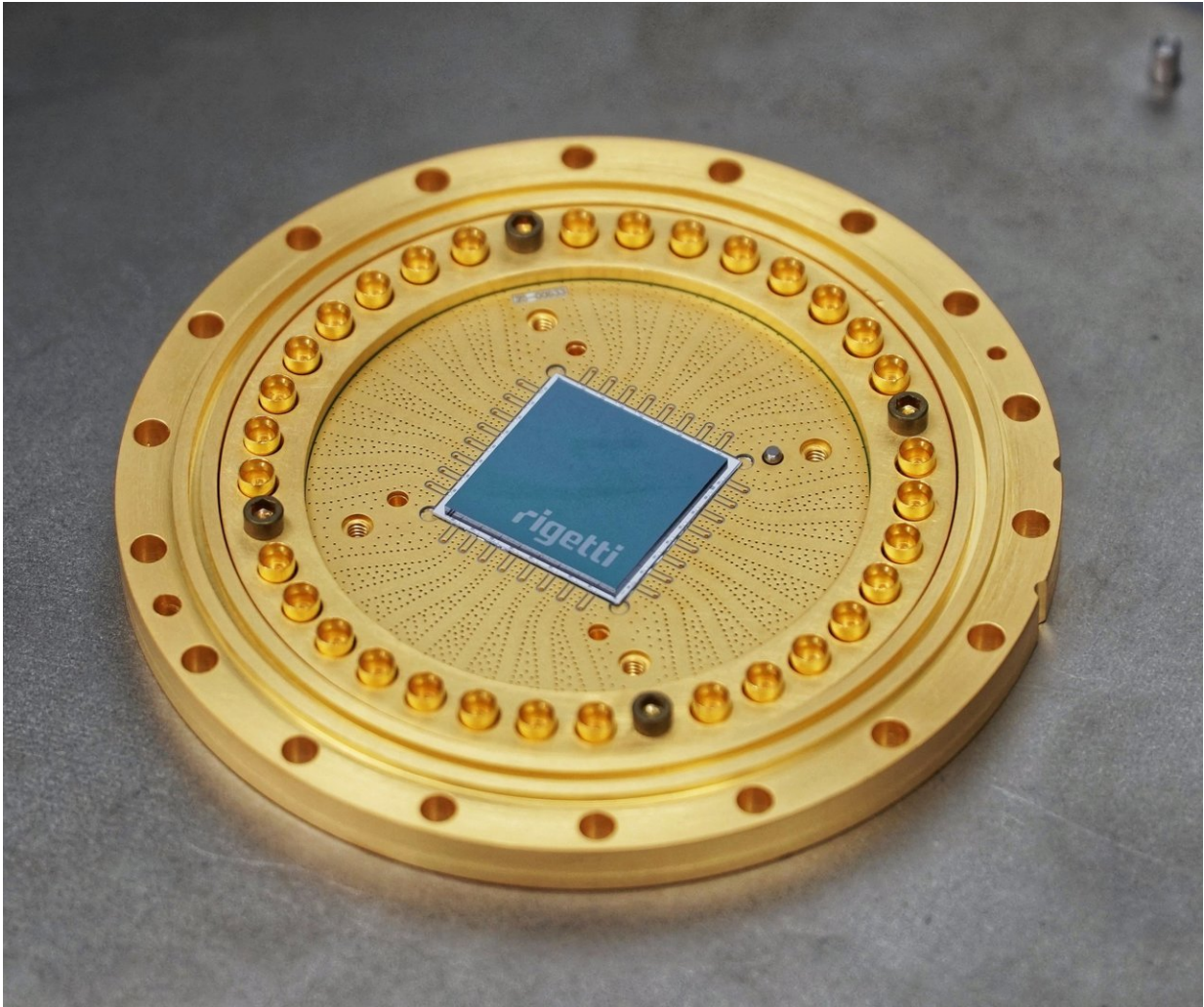


New controls scale quantum chips

February 5 2018



Rigetti's 19Q superconducting quantum processor. Credit: Rigetti Computing

A fundamental barrier to scaling quantum computing machines is "qubit

interference." In new research published in *Science Advances*, engineers and physicists from [Rigetti Computing](#) describe a breakthrough that can expand the size of practical quantum processors by reducing interference.

Matt Reagor, lead author of the paper, says, "We've developed a technique that enables us to reduce interference between qubits as we add more and more qubits to a chip, thus retaining the ability to perform logical operations that are independent of the state of a (large) quantum register."

To explain the concept, the Rigetti team employs [wine glasses](#) as an analogy to qubits:

Clink a wine glass, and you will hear it ring at its resonant [frequency](#) (usually around 400 Hz). Likewise, soundwaves at that frequency will cause the same glass to vibrate. Different shapes or amounts of liquid in a glass will produce different clinks, i.e. different resonance frequencies. A clinked wine glass will cause identical, nearby glasses to vibrate. Glasses that are different shapes are "off-resonant glasses," meaning they will not vibrate much at all.

So, what's the relation between glasses and qubits?

Reagor explains that each physical [qubit](#) on a superconducting quantum processor stores energy in the form of an oscillating electric current. "Think of each qubit as a wine glass," he says. "The logical state of a qubit (e.g. "0" or "1") is encoded by the state of its corresponding electric currents. In our analogy, this is equivalent to whether or not a wine glass is vibrating."

A highly successful class of entangling gates for superconducting qubits operates by tuning two or more qubits into resonance with each other. At

this tuning point, the "wine glasses" pick up on one another's "vibrations."

This effect can be strong enough to produce significant, conditional vibration changes that can be leveraged as conditional logic. Imagine pouring or siphoning off wine from one of the glasses to make this tuning happen. With qubits, there are tunable circuit elements that fulfill the same purpose.

"As we scale up quantum processors, there are more and more wine glasses to manage when executing a specific conditional logic gate," says Reagor. "Imagine lining up a handful of identical glasses with increasing amounts of wine. Now we want to tune one glass into resonance with another, without disturbing any of the other glasses. To do that, you could try to equalize the [wine](#) levels of the glasses. But that transfer needs to be instantaneous to not shake the rest of the glasses along the way. Let's say one glass has a resonance at one frequency (call it 400 Hz) while another, nearby glass has a different one (e.g. 380 Hz). Now, we make use of a somewhat subtle musical effect. We are actually going to fill and deplete one of the glasses repeatedly."

He continues: "We repeat that filling operation at the difference frequency between the glasses (here, 20 times per second, or 20 Hz). By doing so, we create a beat-note for this [glass](#) that is exactly resonant with the other. Physicists sometimes call this a parametric process. Our beat-note is "pure"—it does not have frequency content that interferes with the other glasses. That's what we have demonstrated in our recent work, where we navigated a complex eight-qubit processor with parametric two-qubit gates."

Reagor concludes: "While this analogy may sound somewhat fanciful, its mapping onto our specific technology, from a mathematical standpoint, is surprisingly accurate."

More information: "Demonstration of universal parametric entangling gates on a multi-qubit lattice" *Science Advances* (2018). [DOI: 10.1126/sciadv.aao3603](https://doi.org/10.1126/sciadv.aao3603) , advances.sciencemag.org/content/4/2/eaao3603

Provided by Rigetti Computing

Citation: New controls scale quantum chips (2018, February 5) retrieved 9 April 2024 from <https://phys.org/news/2018-02-scale-quantum-chips.html>

| |
|--|
| <p>This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.</p> |
|--|