

Google has a useful quantum algorithm that outperforms a supercomputer

That system is a small molecule in a Nuclear Magnetic Resonance (NMR) machine. In a second draft paper being published on the arXiv later today, Google has collaborated with a large collection of NMR experts to explore that use.

From computers to molecules

NMR is based on the fact that the nucleus of every atom has a quantum property called spin. When nuclei are held near to each other, such as when they're in the same molecule, these spins can influence one another. NMR uses magnetic fields and photons to manipulate these spins and can be used to infer structural details, like how far apart two given atoms are. But as molecules get larger, these spin networks can extend for greater distances and become increasingly complicated to model. So NMR has been limited to focusing on the interactions of relatively nearby spins.

For this work, though, the researchers figured out how to use an NMR machine to create the physical equivalent of a quantum echo in a molecule. The work involved synthesizing the molecule with a specific isotope of carbon (carbon-13) in a known location in the molecule. That isotope could be used as the source of a signal that propagates through the network of spins formed by the molecule's atoms.

"The OTOC experiment is based on a many-body echo, in which polarization initially localized on a target spin migrates

through the spin network, before a Hamiltonian-engineered time-reversal refocuses to the initial state,” the team wrote. “This refocusing is sensitive to perturbations on distant butterfly spins, which allows one to measure the extent of polarization propagation through the spin network.”

Naturally, something this complicated needed a catchy nickname. The team came up with TARDIS, or Time-Accurate Reversal of Dipolar InteractionS. While that name captures the “out of time order” aspect of OTOC, it’s simply a set of control pulses sent to the NMR sample that starts a perturbation of the molecule’s network of nuclear spins. A second set of pulses then reflects an echo back to the source.

<https://arstechnica.com/science/2025/10/google-claims-to-have-quantum-advantage-with-a-potentially-useful-algorithm/>