Quantum contextuality explained: the magic square game on Google's Willow processor

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Short answer: Google Research reports, in a paper published in Science, that its Willow superconducting processor wins the "magic square" game 98.30% of the time, against a best-possible classical rate of 88.89%, and that the advantage over classical strategies holds in tasks on up to 105 qubits. Google Research described the work on 19 November 2026. It matters because it measures quantum contextuality, a resource that theory links to the power of some quantum algorithms, on real hardware at scale.

TL;DR The short version

- Google reported on 19 November 2026 that its Willow processor won the quantum magic square game 98.30% of the time, against a classical limit of 88.89%.
- The result measures quantum contextuality, a resource theory links to the power of some quantum algorithms, on hardware of up to 105 qubits.
- It demonstrates a quantum resource, not a useful application, and shows how progress can be checked against a known classical bound.

Read online, listen to it, or change the text size: https://blogs.iictp.org/quantum-contextuality-magic-square-willow-explained

What is the magic square game?

Draw a 3×3 grid of +1 and −1 where every row multiplies to +1 and every column multiplies to −1. No such grid exists, because the rows force an even number of −1 entries and the columns force an odd number. In the game, Alice gets a row and Bob gets a column, they cannot communicate, and they win if they put the same value in the cell where their row and column cross. Any pre-agreed plan is a fixed table, so classical players win at most 8 rounds in 9, or 88.89%.

How it works: contextuality, not just entanglement

In the quantum version, Alice and Bob each hold two qubits and share two entangled Bell pairs. They measure with preset settings for their row or column. In the post's explanation, no cell has a value fixed in advance; each answer takes shape only when it is measured with the rest of its row or column, which is its context, and the shared entanglement makes their answers agree at the crossing cell. Contextuality is the testable statement that a measurement result can depend on which compatible measurements are made alongside it.

What is new compared with earlier work

The post says contextuality had been shown almost entirely in systems of a few particles, and that the open question was whether it survives and stays useful on larger machines. The paper, “Quantum-classical separation in bounded-resource tasks arising from measurement contextuality”, reports demonstrations that range up to 105 qubits.

Results reported by the source

- The qubits won the magic square game 98.30% (0.9830 ± 0.0001) across 100,000 plays of each of the nine versions, about one loss in sixty, which the authors attribute to hardware noise.
- The best classical strategy cannot exceed 88.89%.
- The team also exceeded the classical limit on a Bell–Kochen–Specker-type inequality that bundles correlations into a single number, χ. The exact χ values were not read.

Limitations and open questions

- This is a Google blog description of a result published in Science; the full paper was not read, only the research blog post.
- A game that classical players provably cannot win is a demonstration of a quantum resource. It is not a claim of a useful commercial speed-up.
- The post links contextuality to algorithmic power as “a growing body of theory”; that link is a theoretical claim, not something this experiment proves.

What it means for technology teams

For most engineers the practical takeaway is about how quantum progress is measured: with tests where the classical limit is known in advance, so a result can be checked against a hard bound. If your organisation plans for post-quantum cryptography, that work is separate from this result; see post-quantum Privacy Pass and Q-day planning.

Frequently asked questions

- **What is quantum contextuality?** The property that a measurement outcome can depend on which other compatible measurements are made with it, so values cannot be fixed in advance.
- **Is 98.30% proof of quantum advantage for useful work?** No. It shows a measurable separation from classical strategies in a defined game.
- **What processor was used?** The post says Google’s Willow quantum processor.

Related reading

- Post-quantum Privacy Pass and Q-day planning
- What is zero trust?
- The TPBOK standard covers how practitioners weigh emerging technology.

Sources and currency

Sources were read on 22 November 2026. Products, rules and standards change, so check the linked originals before you rely on any detail.

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Sources and further reading

1. Google Research. A game you cannot win unless you have a quantum computer. 19 November 2026. research.google/blog/a-game-you-cannot-win-unless-you-have-a-quantum-computer.

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