

Entangled Particles Satellite Experiments

Spooky action at a distance.”

In the simplest terms, quantum entanglement means that aspects of one particle of an entangled pair depend on aspects of the other particle, no matter how far apart they are or what lies between them. These particles could be, for example, electrons or photons, and an aspect could be the state it is in, such as whether it is “spinning” in one direction or another.

The strange part of quantum entanglement is that when you measure something about one particle in an entangled pair, you immediately know something about the other particle, even if they are millions of light years apart. This odd connection between the two particles is instantaneous, seemingly breaking a fundamental law of the universe. Albert Einstein famously called the phenomenon “spooky action at a distance.” [1]

As the Journal’s Editor I was interested in the reported results of satellite experiments with respect to particle entanglement, and I asked ChatGPT for assistance:

“Could you please describe the Japanese satellite experiment demonstrating the instantaneous reaction of entangled particles to changes over large distances in a technical article with references?”

Here’s a technical description of the *real* space-based quantum entanglement experiments related to satellites, with attention to what has actually been demonstrated and what the physics really implies about “instantaneous reactions” of entangled particles.

Note: No published Japanese satellite experiment has *directly* demonstrated instantaneous state change across large distances in violation of relativity — such a claim would conflict with fundamental quantum mechanics. However, work on quantum entanglement sources in space typically aims to *distribute* entangled pairs and test Bell correlations under space conditions (including Japanese participation in nanosatellite missions). Below is a technically sourced overview with references.

SpooQy-1: CubeSat Demonstration of Entangled Photon Generation

Mission summary:

- *SpooQy-1* was a 3-unit nanosatellite carrying a miniaturized source of entangled photon pairs. It was deployed into Low Earth Orbit (LEO) from the International Space Station in June 2019. (eoportal.org)
- The satellite’s payload, the Small Photon Entangling Quantum System (SPEQS-2), produced polarization-entangled photon pairs via spontaneous parametric down-conversion (SPDC). ([arXiv](https://arxiv.org))
- Onboard polarization measurements were made in different bases; correlations were recorded that violated the Clauser–Horne–Shimony–Holt (CHSH) Bell inequality with an S-parameter around 2.60 ± 0.06 , demonstrating genuine entanglement in space. (academia.edu)
- This demonstrated that quantum entanglement survives the space environment (vacuum, temperature swings, vibration) and that a CubeSat-class platform can host an entanglement source — a prerequisite for space-to-ground entanglement distribution. (optica.org)
- The experiment did *not* send entangled pairs across large distances to ground stations; rather, it established the feasibility of space-based entanglement generation. This is often interpreted as groundwork for future global quantum networks involving satellites.

Reference: Results described at Optica and in research literature show entanglement correlations were detected onboard and verify entanglement integrity in LEO with CHSH > 2. [2]

SOCRATES/SOTA Quantum Key Distribution Tests

Japan's SOCRATES microsatellite (with the SOTA optical communications terminal) performed early quantum key distribution (QKD) tests from space:

- It successfully transmitted quantum-limited polarization signals from orbit to a ground station, achieving quantum bit error rates compatible with QKD protocols. ([arXiv](#))
- While this was not explicitly a Bell test entanglement experiment, it demonstrated quantum signal transmission through space, a companion technology for future entanglement distribution systems. ([arXiv](#))

Related: Micius — The First Dedicated Quantum Entanglement Satellite

Although not Japanese, the Chinese QUESS/Micius satellite is directly relevant because it *has* distributed entanglement across large distances:

- The Micius satellite generated entangled pairs and sent them simultaneously to two ground stations separated by over 1,200 km. Measurements at the ground stations showed residual entanglement and violation of Bell inequalities even over such long paths. ([Wikipedia](#))
- The experiment provided a Bell test in space-to-ground configuration, confirming that quantum correlations persist over distances far beyond previous terrestrial free-space links. ([arXiv](#))
- These experiments confirm that quantum entanglement correlations can be preserved over long distances, consistent with quantum mechanical predictions, but they *do not* allow faster-than-light communication. ([Wikipedia](#))

Reference: Yin et al., “Satellite-Based Entanglement Distribution Over 1200 km”, arXiv (2017). ([arXiv](#)) [3]

What These Space Experiments *Do* Demonstrate

From a technical standpoint, space-based quantum experiments such as *SpoQy-1* and *Micius* demonstrate:

1. Generation and detection of entangled photon pairs in orbit — entanglement sources can operate in LEO conditions. ([optica.org](#))
2. Persistence of quantum correlations over long optical free-space links, including space-to-ground distances exceeding 1,000 km, with measured violation of Bell inequalities at ground receivers. ([Wikipedia](#))
3. Feasibility of satellite-based quantum key distribution protocols that leverage entanglement for secure communications. ([arXiv](#))
4. Confirmation that quantum entanglement is a robust resource for future quantum networks spanning between space and Earth. ([Wikipedia](#))

However, these experiments do not provide a mechanism for instantaneous communication or signaling:

- The measurement outcomes on entangled particles are correlated but individually random. There is no way to *control* the outcome on one end to convey information to the distant end.
- Correlation statistics that demonstrate entanglement require classical communication between observers to compare measurement settings and outcomes.
- This is consistent with quantum theory and relativistic causality.

Summary

Japanese satellite missions like *SpooQy-1* have demonstrated entangled photon generation and Bell inequality violations in orbit, providing essential technology for future quantum networks. ([optica.org](#)) Entanglement correlations observed in those and related international experiments (e.g., Micius) are consistent with quantum mechanics and *do not enable faster-than-light communication*, though they show that entanglement persists over large distances. ([Wikipedia](#))

References

[1] <https://www.astronomy.com/science/what-is-quantum-entanglement-a-physicist-explains-einsteins-spooky-action-at-a-distance/>

[2] Results described at Optica and in research literature ([optica.org](#))

[3] Yin et al., “Satellite-Based Entanglement Distribution Over 1200 km”, arXiv (2017)

[4] Suggested References for Deeper Reading

1. Turner et al., “Entanglement demonstration on board a nano-satellite,” *Optica*, showing onboard entanglement generation and Bell inequality tests. ([optica.org](#))
2. Yin et al. (2017), *arXiv*: Satellite-based entanglement distribution over 1200 km. ([arXiv](#))

Technical overviews of space quantum nodes in “Realizing quantum nodes in space...” *arXiv* (Perumangatt et al.). ([arXiv](#))