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## PRESS RELEASE

Geneva | 13 May 2025

# Remote Particle Measurement via Quantum Entanglement

A UNIGE team has shown that particles can be measured jointly without bringing them together — a key advance for quantum communication and computing.

Quantum physics keeps challenging our intuition. Researchers at the University of Geneva (UNIGE) have shown that joint measurements can be carried out on distant particles, without the need to bring them together. This breakthrough relies on quantum entanglement — the phenomenon that links particles across distance as if connected by an invisible thread. The discovery opens up exciting prospects for quantum communication and computing, where information becomes accessible only once it is measured. The team has also compiled a “catalogue” classifying different types of measurements and the number of entangled particles required for each. The study is published in *Physical Review X*.

By breaking away from the laws of classical physics, quantum physics has opened the door to describing the behaviour of atoms and particles. This science, which explores the most fundamental building blocks of nature, relies in particular on the ability to measure their individual and collective properties. But such measurements are notoriously challenging: the instruments used are themselves governed by quantum laws, and their interaction with particles can alter the very properties they are meant to observe.

“The field of quantum measurements is still poorly understood because it has received little attention so far. Until now, research has mainly focused on the states of quantum systems themselves, which feature properties — like entanglement or superposition — that are more directly applicable to areas such as quantum cryptography or quantum computing,” explains Alejandro Pozas Kerstjens, Senior Research and Teaching Assistant in the Department of Applied Physics, Physics Section, at the UNIGE Faculty of Science.

### Particles linked by an invisible thread

These measurements are essential for the development of future technologies such as quantum communication, which relies on encoding information into, for instance, particles of light (photons). To access this information, the particles must first be measured. A central question is whether it’s possible to perform a joint measurement on two or more separate particles — each carrying part of the information — without physically bringing them together.

In a new study, a team from the UNIGE Department of Physics composed of Jef Pauwels, Alejandro Pozas Kerstjens, Flavio Del Santo, and Nicolas Gisin, demonstrates that certain simple yet fundamental measurements can be performed on separate particle systems, as long as the measurement devices share entangled particles. Entanglement, a cornerstone of quantum physics, links two or more

High resolution pictures

particles so that the state of one instantly determines the state of the other. Measuring one particle immediately reveals the corresponding property in the other, regardless of the distance between them.

“However, there’s a twist: depending on their complexity, some measurements require more — or fewer — entangled particles to be performed properly,” explains Alejandro Pozas Kerstjens. To address this, the research team has developed a classification system — a kind of catalogue — that maps out different types of measurements and the entanglement resources needed to carry them out.

### **Promising applications**

These results represent a step toward a more systematic understanding of measurements in quantum systems. They could find applications not only in quantum communication but also in quantum computing. For instance, in classical computer simulations, calculations are split across multiple machines, and the results are then brought together. A similar approach is being considered for quantum computers, but here, reading the results involves performing measurements across several machines.

“Thanks to our joint remote measurement protocols, it would be possible to eliminate the need for centralization: each quantum computer would measure its own part, and the overall result could be reconstructed without any physical transfer of data. This is a promising direction that we plan to explore further,” concludes the researcher.

## contact

### **Alejandro Pozas Kerstjens**

Senior Research and Teaching Assistant  
Department of Applied Physics  
Physics Section  
Faculty of Science  
UNIGE

+41 22 379 05 10  
Alejandro.Pozaskerstjens@unige.ch

**DOI: [10.1103/PhysRevX.15.021013](https://doi.org/10.1103/PhysRevX.15.021013)**

**UNIVERSITÉ DE GENÈVE**  
**Communication Department**  
24 rue du Général-Dufour  
CH-1211 Geneva 4  
Tel. +41 22 379 77 17  
media@unige.ch  
www.unige.ch