Two crystals linked by quantum physics

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Physicists take a perverse pleasure in playing with the strangeness of the quantum world. That's how they have managed to entangle minuscule objects such as photons. After specific manipulations, they persuade two photons to act as a single entity, even though they are separated by several kilometers. A breakthrough has just been made in this endeavor since a team from the University of Geneva has succeeded in entangling not minuscule objects, but macroscopic crystals.

For almost fifteen years Professor Nicolas Gisin and his physicist col- laborators have been entangling photons. If this exercise seems to them perhaps henceforth trivial, it continues to elude us ordinary humans. The laws that govern the quantum world are so strange that they completely escape us human beings confronted with the laws of the macroscopic world. This apparent difference in nature between the infinitesimally small and our world poses the question of what link exists between the two.

However these two worlds do interact. To realise this, one must fol- low the latest experiment of the Group of Applied Physics (GAP). Nico- las Gisin, researcher Mikael Afzelius and their team have actually pro- duced the entanglement of two macroscopic crystals, visible to the naked eye, thanks to a quantum particle, a photon, otherwise known as a particle of light.

To achieve this exploit, the physicists developed a complex device to which they hold the key. After a first system that allows them to verify that they've actually managed to release one, and only one, photon, a condition essential to the success of the experiment, a second de- vice "slices" this particle in two. This splitting allows the researchers to obtain two entangled photon halves. In other words, even though they are not in the same location, the two halves continue to behave as if they were one.

Wait for the photons to exit

The two halves are then each sent through a separate crystal where they will interact with the neodymium atoms present in its atomic structure. At that moment, because they are excited by these entan- gled photons, the neodymium lattices in each crystal likewise become entangled. But how can we be certain that they've actually reacted to the two photon halves?

That's simple ... or nearly! They just have to wait for the two particles to exit the crystals - since they exit after a rather brief period of about 33 nanoseconds - and to verify that it really is the entangled pair. "That's exactly what we found since the two photons that we cap- tured exiting the crystals showed all the properties of two quantum particles behaving as one, characterised by their simultaneity in spite of their separation", Félix Bussières rejoices, one of the authors of the article.

In addition to its fundamental aspect, this experiment carries with it potential applications. Actually, for the specialists in quantum entan- glement, this phenomenon has the unpleasant habit of fading when the two entangled quantum objects are too far from one another. This is problematic when one envisions impregnable quantum cryp- tography networks which could link two distant speakers separated by several hundreds or even thousands of kilometres.

"Thanks to the entanglement of crystals, we can now imagine inven- ting quantum repeaters", Nicolas Gisin explains, "in other words, the sorts of terminals that would allow us to relay entanglement over large distances. We could then also create memory for quantum com- puters."

Entanglement still has many surprises in store for us.

Provided by University of Geneva