# To test the effect of gravity on quantum entanglement, we need to go to space

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Darth Vader's stormtroopers haven't figured it out. Credit: rpenalozan, CC BY-NC-SA

There is an up-and-coming set of technologies that uses the strange properties of atomic particles predicted by the theory of quantum mechanics, which is the physics of the very small stuff. This technology promises to bring us computers that are faster than all the machines we have ever produced before put together, as well as communication tools no snooping agency can break into and even the capacity to look into the Earth without digging.

At the heart of these technologies is a strange phenomenon called "quantum entanglement". It says that the properties of an atomic particle depend on the properties of another, distant particle, even if there is no physical connection between them. When the properties of one particle change, the twin particle's properties change too.

Now consider that the properties of the first particle could somehow be programmed. If this is encoded in, say, London then its pair in, say, New York will change properties instantaneously. Decoding those properties will mean the transfer of data from London to New York without the need for wires.

Current communication technologies rely on transmission of data over large distances, including Earth-satellites links. If we want to exploit the quantum advantages, we need to transmit quantum properties in such long length scales. For now, however, such quantum communication has been shown to be feasible only at a distance of a little more than 100km. For it to be truly useful it needs to be useful between, at least, satellites and the Earth.

But testing quantum mechanics at larger distances is difficult. The problem arises because gravity gets in the way. Albert Einstein's work on gravity has stood the test of time, but it only explains phenomena at large scale, such as planets and stars. It failed at the level of atoms. In short, we don't understand how tiny particles are affected by gravity.

And so far pitting Einstein's theory against quantum mechanics hasn't been achieved experimentally. It remains one of the biggest challenges in physics. But there may be a solution in an experiment we recently proposed in the *New Journal of Physics*.

In our idea, two quantum particles are prepared in an entangled state in between two different satellites orbiting the Earth. As long as they stay in the same orbit, the entanglement exists. However, at some point the orbit of one of the satellite needs to be changed. This is done by firing engines and accelerating to the new location.

The acceleration needed to change orbit is determined by the gravitational forces acting on the satellite: the more distant the new orbit we want to reach, the larger the time that the engines must be switched on to get the required velocity. This is due to the fact that gravity is more intense if the object is closer to the Earth.

We find that such acceleration – and thus, indirectly, gravity – changes the quality of entanglement between the two particles. If our calculations are right, this could be the first experimental proof that shows that gravity will have indirect effects on quantum entanglement. Also, if quantum technology has to be used in space, it is vital that this be taken into consideration.



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