Reflecting light off satellite backs up Wheeler's quantum theory thought experiment

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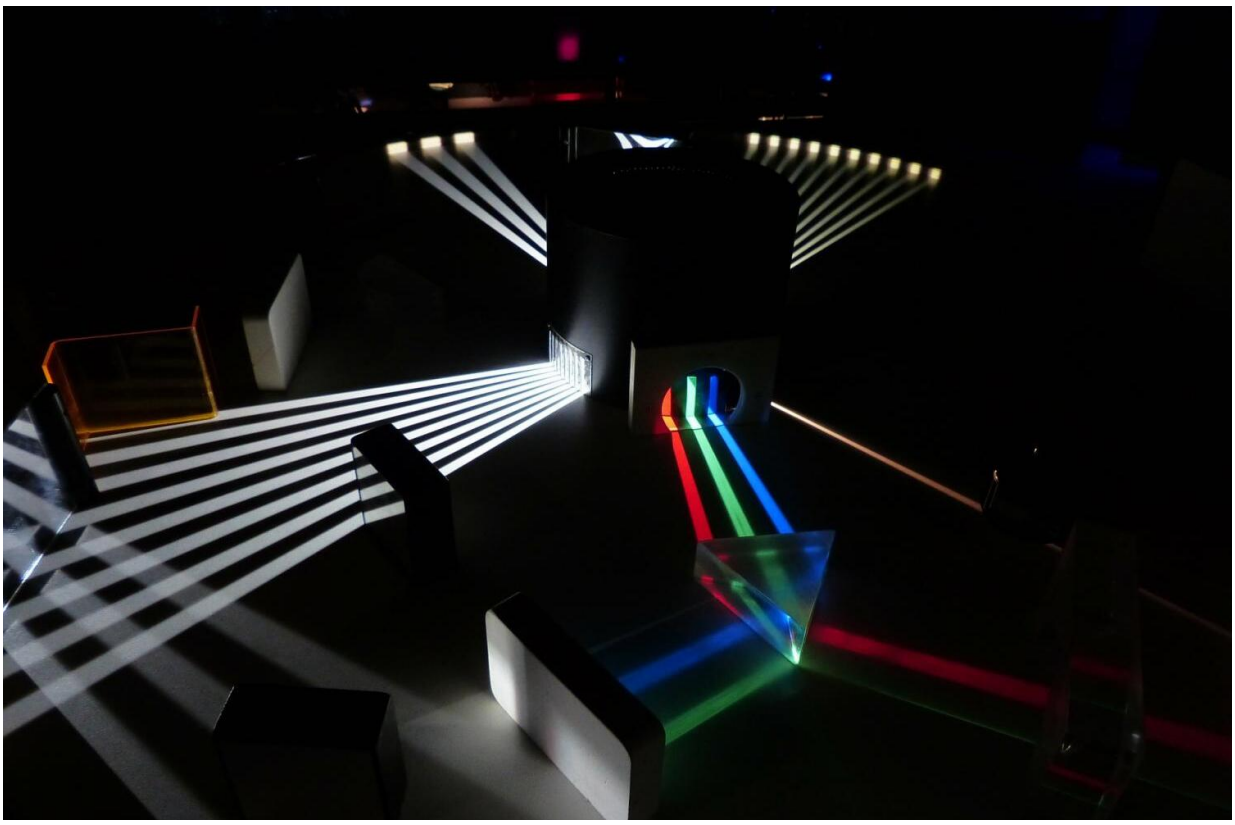

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A team of researchers with Università degli Studi di Padova and the Matera Laser Ranging Observatory in Italy has conducted experiments

that add credence to John Wheeler's quantum theory thought experiment. In their paper published on the open access site *Science Advances*, the group describes their experiment and what they believe it showed.

The nature of light has proven to be one of the more difficult problems facing physicists. Nearly a century ago, experiments showed that light behaved like both a particle and a wave, but subsequent experiments seemed to show that light behaved differently depending on how it was tested, and weirdly, seemed to know how the researchers were testing it, changing its behavior as a result.

Back in the late 1970s, physicist Johan Wheeler tossed around a thought experiment in which he asked what would happen if tests allowed researchers to change parameters after a photon was fired, but before it had reached a sensor for testing—would it somehow alter its behavior mid-course? He also considered the possibilities as light from a distant quasar made its way through space, being lensed by gravity. Was it possible that the light could somehow choose to behave as a wave or a particle depending on what scientists here on Earth did in trying to measure it? In this new effort, the team in Italy set out to demonstrate the ideas that Wheeler had proposed—but instead of measuring light from a quasar, they measured light bounced from a satellite back to Earth.

The experiment consisted of shooting a laser beam at a beam splitter, which aimed the beam at a satellite traveling in low Earth orbit, which reflected it back to Earth. But as the light traveled back to Earth, the researchers had time to make a choice whether or not to activate a second beam splitter as the light was en route. Thus, they could test whether the light was able to sense what they were doing and respond accordingly. The team reports that the light behaved just as Wheeler had predicted—demonstrating either particle-like or wave-like behavior,

depending on the behavior of those studying it.

More information: Francesco Vedovato et al. Extending Wheeler's delayed-choice experiment to space, *Science Advances* (2017). DOI: 10.1126/sciadv.1701180

Abstract

Gedankenexperiments have consistently played a major role in the development of quantum theory. A paradigmatic example is Wheeler's delayed-choice experiment, a wave-particle duality test that cannot be fully understood using only classical concepts. We implement Wheeler's idea along a satellite-ground interferometer that extends for thousands of kilometers in space. We exploit temporal and polarization degrees of freedom of photons reflected by a fast-moving satellite equipped with retroreflecting mirrors. We observe the complementary wave- or particle-like behaviors at the ground station by choosing the measurement apparatus while the photons are propagating from the satellite to the ground. Our results confirm quantum mechanical predictions, demonstrating the need of the dual wave-particle interpretation at this unprecedented scale. Our work paves the way for novel applications of quantum mechanics in space links involving multiple photon degrees of freedom.

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