Feynman's double-slit experiment brought to life

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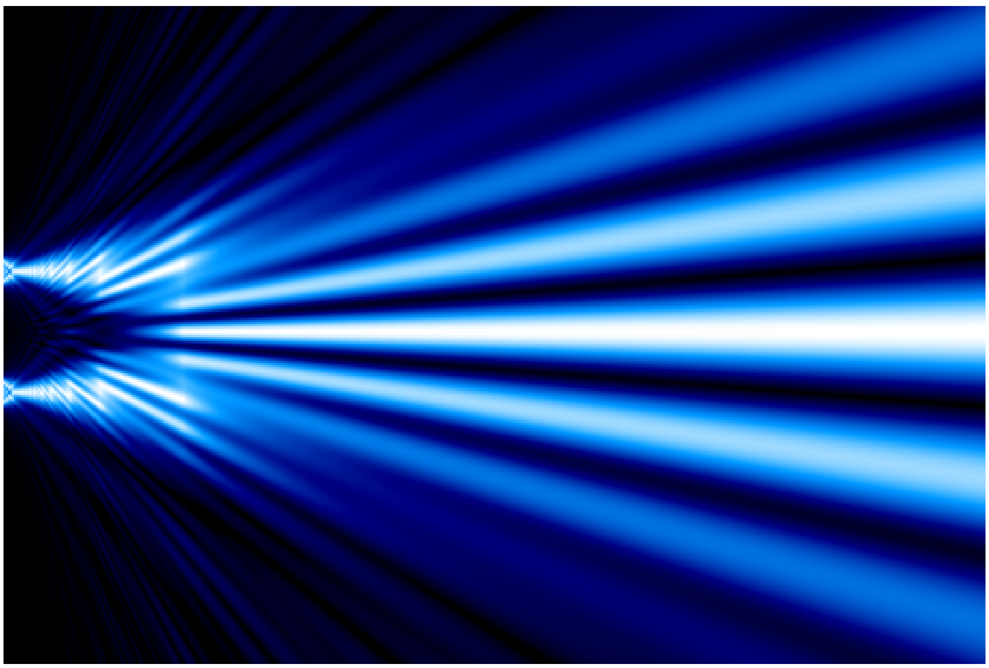

(Phys.org) —The precise methodology of Richard Feynman's famous double-slit thought-experiment – a cornerstone of quantum mechanics that showed how electrons behave as both a particle and a wave – has been followed in full for the very first time.

Although the particle-wave duality of electrons has been demonstrated in a number of different ways since Feynman popularised the idea in 1965, none of the experiments have managed to fully replicate the methodology set out in Volume 3 of Feynman's famous Lectures on Physics.

"The technology to do this experiment has been around for about two decades; however, to do a nice data recording of electrons takes some serious effort and has taken us three years," said lead author of the study Professor Herman Batelaan from the University of Nebraska-Lincoln.

"Previous double-slit experiments have successfully demonstrated the mysterious properties of electrons, but none have done so using Feynman's methodology, specifically the opening and closing of both slits at will and the ability to detect electrons one at a time.

"Akira Tonomura's brilliant experiment used a thin, charged wire to split electrons and bring them back together again, instead of two slits in a wall which was proposed by Feynman. To the best of my knowledge, the experiments by Guilio Pozzi were the first to use nano-fabricated slits in a wall; however, the slits were covered up by stuffing them with material so could not be open and closed automatically."

In their experiments, which have been published today in the *New Journal of Physics*, Batelaan and his team, along with colleagues at the Perimeter Institute of Theoretical Physics, created a modern representation of Feynman's experiment by directing an electron beam, capable of firing individual electrons, at a wall made of a gold-coated silicon membrane.

The wall had two 62-nm-wide slits in it with a centre-to-centre separation of 272 nm. A 4.5 µm wide and 10 µm tall moveable mask, controlled by a piezoelectric actuator, was placed behind the wall and slid back and forth to cover the slits.

"We've created an experiment where both slits can be mechanically opened and closed at will and, most importantly, combined this with the capability of detecting one electron at a time.

"It is our task to turn every stone when it comes to the most fundamental experiments that one can do. We have done exactly that with Feynman's famous thought-experiment and have been able to illustrate the key feature of quantum mechanics," continued Batelaan.

Feynman's double-slit experiment

In Feynman's double-slit thought-experiment, a specific material is randomly directed at a wall which has two small slits that can be opened and closed at will – some of the material gets blocked and some passes through the slits, depending on which ones are open.

Based on the pattern that is detected beyond the wall on a backstop – which is fitted with a detector – one can discern whether the material coming through behaves as either a wave or particle.

When particles are fired at the wall with both slits open, they are more likely to hit the backstop in one particular area, whereas waves interfere with each other and hit the backstop at a number of different points with differing strength, creating what is known as an interference pattern.

In 1965, Feynman popularised that electrons – historically thought to be particles – would actually produce the pattern of a wave in the double-split experiment.

Unlike sound waves and water waves, Feynman highlighted that when electrons are fired at the wall one at a time, an interference pattern is still produced. He went on to say that this phenomenon "has in it the heart of quantum physics [but] in reality, it contains the only mystery."

More information: "Controlled double-slit electron diffraction" Roger Bach et al 2013 *New J. Phys.* 15 033018
iopscience.iop.org/1367-2630/15/3/033018/article

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