

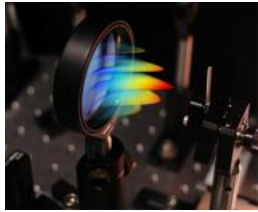
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Wave function directly measured

Canadian team achieves quantum feat that makes the intangible a little more tangible

By Devin Powell

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ENLARGE

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CATCHING A WAVE

The wave function that describes the location of a single particle of light is colorfully depicted in an artist's interpretation, superimposed on an image of the experimental setup.

Jeff Lundeen, Charles Bamber

The fuzzy quantum shape that describes the speed or location of a single particle, its wave function, has now been directly measured in the laboratory, giving this mathematical concept a small dose of reality.

Like a bubble on the breeze, the wave function usually disappears when poked or prodded for information. But scientists in Canada have worked out a gentler way to touch it, they report June 9 in *Nature*.

"Measuring the wave function itself is not really thought to be a possible thing," says Stanford physicist Onur Hosten. "It's not really thought to be something physical."

This interpretation dates to the 1920s, when physicist Max Born argued that the wave function, represented by the Greek letter psi, is a useful mathematical tool. The equation for the wave function is the starting point, for instance, for drawing the colorful shapes in chemistry textbooks that show the probability of an electron being in a certain spot.

To calculate a wave function, scientists usually collect lots of indirect measurements using a technique called quantum state tomography.

"It's like working out the shape of a water wave by moving a light around and measuring the wave's shadow on the bottom of the pool,"

says Jeff Lundeen, a physicist at Canada's National Research Council Institute for National Measurement Standards in Ottawa.

Lundeen and colleagues favor a direct interrogation using a combination of strong measurements, which provide the comfort of certainty but destroy the wave function, and weak measurements, which provide uncertain information but do little damage.

To demonstrate how this works in the laboratory, the team measured the wave function that describes the location of a single particle of light, or photon. The team polarized photons so that the angle of each particle gave a rough idea of its location, leaving just enough uncertainty to not disturb the wave function. Eliminating all photons that were moving in a specific direction — a strong measurement of momentum — allowed the scientists to map out the wave function using the still particles that remained.

"This doesn't provide any more information than other methods," says Lundeen. "It just gives it to you in a different way."

Lundeen and his colleagues aren't trying to challenge quantum mechanics. Heisenberg's uncertainty principle, which says that the location and momentum of a single particle can't be simultaneously measured, still holds: Lundeen's team had to weakly measure many light particles to work out the position information.

And all these light particles had to be identical, which could limit the usefulness of the technique.

"The method reported works only if one knows beforehand that every photon is created in the same quantum state," says Michael Raymer, a physicist at the University of Oregon in Eugene. "This is generally not the case, and in this case one would need to use the standard methods of quantum state tomography."

Still, Lundeen says this new probe can probably be adapted to measure the wave functions of many other particles — including ions, molecules and electrons.

SUGGESTED READING :

I. Peterson. Mapping helium atoms' quantum states. Science News. Vol. 151, March 15, 1997, p. 158. Available online:

O. Hosten. How to catch a wave. Nature. Vol. 474, June 9, 2011, p. 170.

P. Weiss. Molecular anatomy revealed. Science News. Vol. 167, May 21, 2005, p. 330. Available online:

The American Institute of Physics, for more on Niels Bohr and the 1920s:

CITATIONS & REFERENCES :

J.S. Lundeen et al. Direct measurement of the quantum wavefunction.

Nature. Vol. 474, June 9, 2011, p. 188. doi:10.1038/nature10120.