# First demonstration of antimatter wave interferometry

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Matter waves constitute a crucial feature of quantum mechanics, in which particles have wave properties in addition to particle characteristics. This wave-particle duality was postulated in 1924 by the French physicist Louis de Broglie. The existence of the wave property of matter has been successfully demonstrated in a number of experiments with electrons and neutrons, as well as with more complex matter, up to large molecules.

For antimatter, the wave-particle duality has also been proven through diffraction experiments. However, researchers of the QUPLAS collaboration have now established wave behavior in a single positron (antiparticle to the electron) interference experiment. The results are reported in *Science Advances*.

The QUPLAS scientific collaboration includes researchers from the University of Bern and from the University and Politecnico of Milano. To demonstrate the wave duality of single positrons, they performed measurements with a setup similar to the so-called double-slit experiment. This setup was suggested by physicists including Albert Einstein and Richard Feynman; it is often used in quantum theory to demonstrate the wave nature of particles.

In the experiment, positrons were directed from a source to a position-sensitive detector. In between, there were gratings with patterns of two or more slits through which the particles travel. Particles behaving like particles travel in straight lines and produce a pattern corresponding exactly to the grating. If the particles have a wave nature, a striped interference pattern appears at the detector that appears different from the grating. The new pattern is generated by the superposition of the waves emitted by the source and traveling through the grating.

The researchers were able to generate such an interference pattern from single antimatter particle waves. It was obtained thanks to an innovative period-magnifying Talbot-Lau interferometer coupled to a nuclear emulsion position-sensitive detector. "With the nuclear emulsions, we are able to determine the impact point of individual positrons very precisely, which allowed us to reconstruct their interferometric pattern with micrometric accuracy—thus to better than a millionth of a meter," explained Dr. Ciro Pistillo of the Laboratory of High Energy Physics (LHEP) and Albert Einstein Center (AEC) of the University of Bern. This feature allowed the researchers to overcome the main limitations of antimatter experiments, namely low antiparticle flux and beam manipulation complexity.

"Our observation of the energy dependence of the interference pattern proves its quantum-mechanical origin and thus the wave nature of the positrons," says Professor Paola Scampoli. The success of the experiment paves the way to a new field of investigations based on antimatter interferometry. A goal is, for example, to perform gravity measurements with exotic matter-antimatter symmetric atoms such as positronium. The researchers hope to test the validity of the weak equivalence principle for antimatter. This principle is at the basis of general relativity and has never been tested with antimatter. Future research fields based on antimatter interferometry could in the future provide information about the imbalance of matter and antimatter in the universe.

**More information:** S. Sala et al. First demonstration of antimatter wave interferometry, *Science Advances* (2019). DOI: 10.1126/sciadv.aav7610

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