

# Subatomic particle seen changing to antiparticle and back

June 8 2021

---



Credit: Brice, Maximilien: CERN

Physicists have proved that a subatomic particle can switch into its antiparticle alter-ego and back again, in a new discovery revealed today.

The extraordinarily precise measurement was made by UK researchers using the Large Hadron Collider beauty (LHCb) experiment at CERN.

It has provided the first evidence that [charm](#) mesons can change into their antiparticle and back again.

## **Mixing phenomenon**

For more than 10 years, scientists have known that charm mesons, [subatomic particles](#) that contain a quark and an antiquark, can travel as a mixture of their particle and antiparticle states.

It is a phenomenon called mixing.

However, this new result shows for the first time that they can oscillate between the two states.

## **Tackling big physics questions**

Armed with this new evidence, scientists can try to tackle some of the biggest questions in physics around how particles behave outside of the Standard Model.

One being, whether these transitions are caused by unknown particles not predicted by the guiding theory.

The research, submitted to *Physical Review Letters* and available on arXiv, received funding from the Science and Technology Facilities Council (STFC).

## **Being one and the other**

In the strange world of quantum physics, the charm [meson](#) can be itself and its antiparticle at once.

This state, known as quantum superposition, results in two particles each with their own mass—a heavier and lighter version of the particle.

This superposition allows the charm meson to oscillate into its antiparticle and back again.

## **Mass differences**

Using data collected during the second run of the Large Hadron Collider (LHC), researchers from the University of Oxford measured a difference in mass between the two particles.

There was a difference of 0.0000000000000000000000000000000000000001 grams—or in scientific notation  $1 \times 10^{-38}$  g.

A measurement of this precision and certainty is only possible when the phenomenon is observed many times.

This is only possible due to many charm mesons being produced in LHC collisions.

As the measurement is extremely precise, the research team ensured the analysis method was even more so.

## **A novel technique**

To do this, the team used a novel technique originally developed by colleagues at the University of Warwick.

There are only four types of particle in the Standard Model, the theory that explains particle physics, that can turn into their antiparticle.

The mixing phenomenon was first observed in Strange mesons in the 1960s and in beauty mesons in the 1980s.

Until now, the only other one of the four particles that has been seen to oscillate this way is the strange-beauty meson, a measurement made in 2006.

## **A rare phenomenon**

Professor Guy Wilkinson at University of Oxford, whose group contributed to the analysis, said:

"What makes this discovery of oscillation in the charm meson particle so impressive is that, unlike the beauty mesons, the oscillation is very slow and therefore extremely difficult to measure within the time that it takes the meson to decay. This result shows the oscillations are so slow that the vast majority of particles will decay before they have a chance to oscillate. However, we are able to confirm this as a discovery because LHCb has collected so much data."

Professor Tim Gershon at University of Warwick, developer of the analytical technique used to make the measurement, said: "Charm meson particles are produced in proton–proton collisions and they travel on average only a few millimeters before transforming, or decaying, into other particles. By comparing the charm meson particles that decay after traveling a short distance with those that travel a little further, we have been able to measure the key quantity that controls the speed of the charm meson oscillation into anti-charm meson—the difference in mass between the heavier and lighter versions of charm meson."

## **A new door opens for physics exploration**

This discovery of charm meson oscillation opens up a new and exciting phase of physics exploration.

Researchers now want to understand the oscillation process itself, potentially a major step forward in solving the mystery of matter-antimatter asymmetry.

A key area to explore is whether the rate of particle-antiparticle transitions is the same as that of antiparticle-particle transitions.

And specifically, whether the transitions are influenced or caused by unknown particles not predicted by the Standard Model.

## **Tiny measurements tell big things**

Dr. Mark Williams at University of Edinburgh, who convened the LHCb Charm Physics Group within which the research was performed, said: "Tiny measurements like this can tell you big things about the Universe that you didn't expect."

The result,  $1 \times 10^{-38} \text{g}$ , crosses the 'five sigma' level of statistical significance that is required to claim a discovery in particle physics.

## **Further information**

LHCb is one of the four large experiments at the LHC at CERN in Geneva, and is designed to study decays of particles containing a beauty quark.

The primary goal of LHCb is to investigate matter-antimatter asymmetry

or "CP violation."

After the Big Bang, matter and antimatter were created in equal amounts, but when they meet they annihilate each other.

As we live in a universe dominated by matter, there must be a subtle difference between matter and antimatter that has allowed matter to survive.

Mesons are part of the large class of particles made up of fundamental particles called quarks, and contain one quark and one antimatter quark.

The D0 meson consists of a charm quark and an up antiquark, and its antiparticle, the anti-D0, consists of a charm antiquark and an up quark.

This measurement was made using LHCb's Vertex Locator (VELO) subdetector.

**More information:** Observation of the mass difference between neutral charm-meson eigenstates. arXiv:2106.03744v1 [hep-ex]  
[arxiv.org/abs/2106.03744](https://arxiv.org/abs/2106.03744)

Provided by UK Research and Innovation

Citation: Subatomic particle seen changing to antiparticle and back (2021, June 8) retrieved 27 April 2024 from <https://phys.org/news/2021-06-subatomic-particle-antiparticle.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.