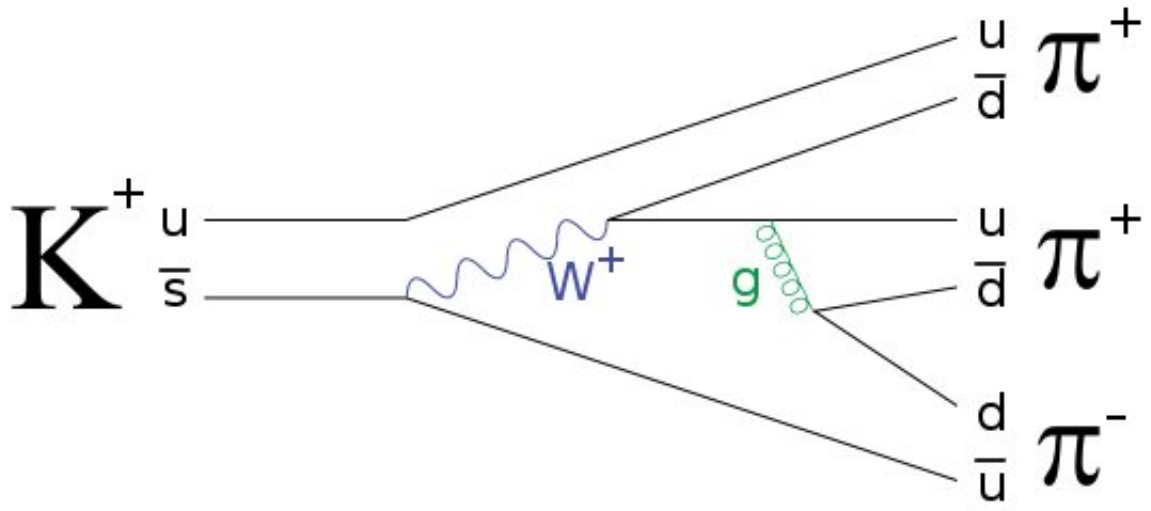
Ultra-rare kaon decay could lead to evidence of new physics

September 23 2019



An example feynman diagram of a kaon decay. A kaon, made of an up and strange antiquark, decays both weakly and strongly into three pions, with intermediate steps involving a W boson and a gluon, represented by the blue sine wave and green spiral, respectively. Credit: JabberWok on en.wikipedia

Scientists searching for evidence of new physics in particle processes that could explain dark matter and other mysteries of the universe have moved one step closer, with the new result of the NA62 experiment reported today at CERN.

The experiment, led by an international team of scientists, demonstrates a new technique which captures and measures the ultra rare decay of a

sub atomic particle called a kaon.

Their results, presented at a CERN Seminar on Monday 23 September, show how precise measurements of this process could hint at new physics, beyond the Standard Model developed in the 1970s.

The Standard Model is still commonly used to describe the fundamental forces and building blocks of the universe and is a highly successful theory, but there are several mysteries of the universe that the Standard Model does not explain, such as the nature of dark matter, or the origins of the matter-antimatter imbalance in the universe. Physicists have been searching for extensions to the Standard Model that can predict new particles or interactions that can explain these phenomena.

The new measurement was made at the CERN particle physics laboratory by a team led by the University of Birmingham. The aim of the experiment, called NA62, is to study the sub-atomic particles kaons, containing the quark strange, and a particular way in which they transform into other types of particles with odds around 1 in 10 billion.

This process is predicted in detail by the Standard Model with an uncertainty of less than 10 percent, so any deviation from that prediction is an exciting clear sign of new physics. By combining the 2016 and 2017 data sets, the team finds that the relative frequency of this process would be at most 24.4 in 100 billion K+ decays. This combined result is compatible with the Standard Model prediction and allows the team to put limits on beyond-Standard Model theories that predict frequencies larger than this upper bound.

"This kaon decay process is called the 'golden channel' because the combination of being ultra-rare and excellently predicted in the Standard model. It is very difficult to capture, and holds real promise for scientists searching for new physics," explains Professor Cristina Lazzeroni,

Professor in Particle Physics at the University of Birmingham, and spokesperson for NA62. "By capturing a precise measurement of the decay we can identify deviations from the Standard Model prediction. The new result has still limited statistics but has already enabled us to begin putting constraints on some new physics models."

The experiment took place over three years at CERN's Prevessin site, in France and involves about 200 scientists from 27 institutions. The aim was to measure precisely how the kaon particle decays into a pion and a neutrino–antineutrino pair using the proton beam from CERN's Super Proton Synchrotron (SPS). The kaons are created by colliding high energy protons from the SPS into a stationary beryllium target. This creates a beam of secondary particles which contains and propagates almost one billion particles per second, about 6% of which are kaons.

Because the process being measured is so rare, the team had to be particularly careful not to do anything that might bias the result. For that reason, the experiment was carried out as a "blind analysis," where physicists initially only look at the background to check that their understanding of the various sources is correct. Only once they are satisfied with that, they look at the region of the data where the signal is expected to be. This "opening of the blind box" was carried out on 10th September at the International Conference on Kaon Physics, KAON2019, held in Perugia, Italy.

Professor Lazzeroni added: "This is a big step forward for the field of particle physics that will enable us to explore new ways to understand our universe. This has been made possible through a huge team effort from all the collaborating institutes and the continuous support of CERN."

The experiment will analyze further data taken in 2018 and publish it next year. There are also plans to take more data to refine the

measurement from 2021 when the CERN SPS will restart operation.

Provided by University of Birmingham