Discovery of new subatomic particle sheds light on fundamental force of nature

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Credit: CERN

The discovery of a new particle will "transform our understanding" of the fundamental force of nature that binds the nuclei of atoms, researchers argue.

Led by scientists from the University of Warwick, the discovery of the new particle will help provide greater understanding of the strong interaction, the fundamental force of nature found within the protons of an atom's nucleus.

Named Ds3*(2860)⁻, the particle, a new type of meson, was discovered by analysing data collected with the LHCb detector at CERN's Large Hadron Collider (LHC) .

The new particle is bound together in a similar way to protons. Due to this similarity, the Warwick researchers argue that scientists will now be able to study the particle to further understand strong interactions.

Along with gravity, the electromagnetic interaction and weak nuclear force, strong-interactions are one of four fundamental forces. Lead scientist Professor Tim Gershon, from The University of Warwick's Department of Physics, explains:

"Gravity describes the universe on a large scale from galaxies to Newton's falling apple, whilst the electromagnetic interaction is responsible for binding molecules together and also for holding electrons in orbit around an atom's nucleus.

"The strong interaction is the force that binds quarks, the subatomic particles that form protons within atoms, together. It is so strong that the binding energy of the proton gives a much larger contribution to the mass, through Einstein's equation E = mc2, than the quarks themselves. "

Due in part to the forces' relative simplicity, scientists have previously been able to solve the equations behind gravity and electromagnetic interactions, but the strength of the strong interaction makes it impossible to solve the equations in the same way.

"Calculations of strong interactions are done with a computationally intensive technique called Lattice QCD," says Professor Gershon. "In order to validate these calculations it is essential to be able to compare predictions to experiments. The new particle is ideal for this purpose because it is the first known that both contains a charm quark and has spin 3."

There are six quarks known to physicists; Up, Down, Strange, Charm, Beauty and Top. Protons and neutrons are composed of up and down quarks, but particles produced in accelerators such as the LHC can contain the unstable heavier quarks. In addition, some of these particles have higher spin values than the naturally occurring stable particles.

"Because the $Ds3^*(2860)^-$ particle contains a heavy charm quark it is easier for theorists to calculate its properties. And because it has spin 3, there can be no ambiguity about what the particle is," adds Professor Gershon. "Therefore it provides a benchmark for future theoretical calculations. Improvements in these calculations will transform our understanding of how nuclei are bound together."

Spin is one of the labels used by physicists to distinguish between particles. It is a concept that arises in quantum mechanics that can be thought of as being similar to angular momentum: in this sense higher spin corresponds to the quarks orbiting each other faster than those with a lower spin.

Warwick Ph.D. student Daniel Craik, who worked on the study, adds "Perhaps the most exciting part of this new result is that it could be the first of many similar discoveries with LHC data. Whether we can use the same technique, as employed with our research into $Ds3^*(2860)^-$, to also improve our understanding of the weak interaction is a key question raised by this discovery. If so, this could help to answer one of the biggest mysteries in physics: why there is more matter than antimatter in the Universe."

The results are detailed in two papers that will be published in the next editions of the journals *Physical Review Letters* and *Physical Review D*. Both papers have been given the accolade of being selected as Editors' Suggestions.

More information: "Observation of overlapping spin-1 and spin-3 D0K- resonances at mass 2.86 GeV/c2", to be published in *Physical Review Letters*: arxiv.org/pdf/1407.7574.pdf

"Dalitz plot analysis of Bs0→D0K-π+ decays", to be published in *Physical Review D*, arxiv.org/pdf/1407.7712.pdf

Provided by University of Warwick