Evidence mounts that neutrinos are the key to the universe's existence

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The T2K near detector. Credit: Imperial College London

New experimental results show a difference in the way neutrinos and antineutrinos behave, which could explain why matter persists over antimatter.

The results, from the T2K experiment in Japan, show that the degree to which neutrinos change their type differs from their antineutrino counterparts. This is important because if all types of matter and antimatter behave the same way, they should have obliterated each other shortly after the Big Bang.

So far, when scientists have looked at matter-antimatter pairs of particles, no differences have been large enough to explain why the universe is made up of matter – and exists – rather than being annihilated by antimatter.

Neutrinos and antineutrinos are one of the last matter-antimatter pairs to be investigated since they are difficult to produce and measure, but their strange behaviour hints that they could be the key to the mystery.

Flavour change

Neutrinos (and antineutrinos) come in three 'flavours' of tau, muon and electron, each of which can spontaneously change into the other as the neutrinos travel over long distances.

The latest results, announced today by a team of researchers including physicists from Imperial College London, show more muon neutrinos changing into electron neutrinos than muon antineutrinos changing into electron antineutrinos.

This difference in muon-to-electron changing behaviour between neutrinos and antineutrinos means they would have different properties, which could have prevented them from destroying each other and allow the universe to exist.

To explore the (anti)neutrino flavour changes, known as osciallations, the T2K experiment fires a beam of (anti)neutrinos from the J-PARC laboratory at Tokai Village on the eastern coast of Japan.

It then detects them at the Super-Kamiokande detector, 295 km away in the mountains of the north-western part of the country. Here, the scientists look to see if the (anti)neutrinos at the end of the beam matched those emitted at the start.

Very intriguing

The latest results were concluded from relatively few data points, meaning there is still a one in 20 chance that the results are due to random chance, rather than a true difference in behaviour. However, the result is still exciting for the scientists involved.

Dr Morgan Wascko, international co-spokesperson for the T2K experiment from the Department of Physics at Imperial said: "This is an important first step towards potentially solving one of the biggest mysteries in science.

"T2K is the first experiment that is able to study neutrino and antineutrino oscillation under the same conditions, and the disparity we have observed is, while not yet statistically significant, very intriguing."

Dr Yoshi Uchida, also from the Department of Physics at Imperial and a principal investigator at T2K, added: "More data is needed to prove conclusively that neutrinos and antineutrinos behave differently, but this result is an indication that neutrinos will continue to provide breakthroughs in our understanding of the universe.

Upgrades to the equipment that produces (anti)neutrinos, as well as to the detector that measures them, are expected to add more data within the next decade, and determine whether the difference is in fact real.

Provided by Imperial College London

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