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Solution to Long-standing Neutrino Puzzle May Be within Reach

Physicists line up to crack a long-standing particle puzzle

By Calla Cofield | Tuesday, December 10, 2013

“Rare” may be too generous a term for the phenomenon called neutrinoless double beta decay, a burst of radioactive emission in which two neutrinos cancel each other out and vanish. To observe the nuclear process in a single atom, you might have to wait trillions of trillions of years—far longer than the age of the universe.

Image: Thomas Fuchs

Then again, neutrinoless double beta decay may not happen at all. No one has ever seen it, but physicists are keen to observe the phenomenon, which would indicate that the beguiling particles known as neutrinos have many new secrets to reveal.

Whereas most hunts in particle physics try to net specific particles in a detector, neutrinoless double beta decay experiments look for a telltale absence of particles. The decay is a variant of double beta decay, a better-understood nuclear process in which radioactive atoms transmute from one element to another (changing, say, from xenon to barium), releasing a pair of electrons and a pair of neutrinos as by-products. But if neutrinos are their own antimatter counterparts, as many physicists suspect, the two neutrinos can cancel out. Experimenters thus look for all the characteristics of double beta decay, minus the neutrinos.

If it exists in nature, the neutrino disappearing act would open up several new realms for investigation. “Neutrinoless double beta decay is the smoking gun for new physics,” says Carter Hall, a physicist at the University of Maryland. Most tantalizing, perhaps, neutrinos and antineutrinos being one and the same would imply that the neutrino does not get its mass from the Higgs boson, as do most of the other elementary particles, but from some other, unresolved mechanism. The dual nature of neutrinos might also help explain why antimatter is so scarce in our universe.

A glimmer of hope appeared in 2001, when a cadre of physicists working on the Heidelberg-Moscow Double Beta Decay Experiment claimed to have caught sight of the exotic decay. But new data have all but extinguished its plausibility. The Germanium Detector Array (GERDA) in Italy, which should by now have been able to corroborate the Heidelberg-Moscow claim, has so far come up empty in its search for neutrinoless double beta decay from a heavy isotope of germanium, physicists reported in September in *Physical Review Letters*. Next year upgrades to the experiment will increase GERDA's sensitivity, pushing into the range where many neutrino researchers predict the phenomenon will be detectable.

Physicists are also sifting through the particles given off by other radioactive atoms for which neutrinoless double beta decay is hypothetically possible. Last year researchers presented early data from new experiments called KamLAND-Zen in Japan and EXO-200 in New Mexico, both of which look for decays from an isotope of xenon. Neither has yet found any evidence for neutrinoless decay, but for the first time in the decades-long pursuit of the elusive phenomenon, physicists have experiments that can get them there.