Physics experiment boosts evidence for sterile neutrinos

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LOS ALAMOS, N.M., March 9, 2021—Analysis of results from an experiment called MiniBooNE at Fermilab has provided yet more evidence that particles called “sterile neutrinos” could indeed exist, supporting results from a 1990s Los Alamos National Laboratory experiment that indicated an update to the Standard Model of physics might be in order.

“We believe that this paper vindicates the Liquid Scintillator Neutrino Detector (LSND) results and that the community accepts that both LSND and MiniBooNE observed more events than expected,” said William Louis of Los Alamos National Laboratory, a member of the MiniBooNE collaboration. “The question is what is causing the excess: Is it a Standard Model background that no one has thought of, or is it a new Beyond the Standard Model process involving sterile neutrinos? Any result that contradicts the Standard Model is guilty until proven innocent, so we need more experiments to confirm and prove these results beyond any shadow of a doubt.”

"What is amazing about the MiniBooNE oscillation results is that they have withstood the test of time - two decades - with more accumulated data, extensive improvements in the analysis and understanding of the experiment, and intense scrutiny from the community," said Richard Van de Water, the MiniBooNE spokesperson from Los Alamos.

A paper in the journal *Physical Review D* this week implies that some of the muon neutrinos measured are flipping to sterile neutrinos before switching identity again to electron neutrinos.

The MiniBooNE experiment at Fermilab was approved in 1998 to test the evidence for neutrino oscillations from the Liquid Scintillator Neutrino Detector experiment that took data at Los Alamos from 1993 to 1998. LSND observed a 3.8 sigma excess of electron-antineutrino candidate events that were consistent with muon-antineutrinos oscillating into electron-antineutrinos.

Neutrino oscillations are a quantum mechanical effect that occurs when neutrinos of a given flavor (e.g. electron-neutrinos or muon-neutrinos) consist of a superposition of two or more masses.

They were shown from the SuperKamiokande experiment in Japan and the SNO experiment in Canada. However, the neutrino oscillation evidence from the Los Alamos LSND experiment occurs at a much shorter distance than the neutrino oscillations at SuperKamiokande and SNO, Louis said, which suggests that there are additional

fundamental neutrinos, so-called sterile neutrinos, than the Standard Model electron-neutrinos, muon-neutrinos, and tau-neutrinos.

The MiniBooNE detector, consisting of a 40-foot diameter spherical tank filled with 800 tons of mineral oil and covered by 1,280 8-inch photomultiplier tubes, was completed and began taking data in 2002 with neutrinos from the Fermilab Booster Neutrino Beam (BNB). After taking data for 17 years, the MiniBooNE detector was turned off in 2019, having collected 18.75×10^{20} protons on target (POT) in neutrino mode and 11.27×10^{20} POT in antineutrino mode. The equipment is currently inactive but available should it be needed for further research.

Exotic models beyond the three-neutrino paradigm that have been invoked to explain the excess events shown by MiniBooNE generally involve sterile neutrinos and include, for example, 3+N neutrino oscillation models involving three active neutrinos and N additional sterile neutrinos, resonant neutrino oscillations, Lorentz violation, sterile neutrino decay, scalar decay, sterile neutrino nonstandard interactions, and altered dispersion relations with sterile neutrinos.

The paper: Updated MiniBooNE neutrino oscillation results with increased data and new background studies, The MiniBooNE Collaboration, Phys. Rev. D 103, 052002 – Published 8 March 2021, DOI: 10.1103/PhysRevD.103.052002

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