NEWS

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Hope fades for neutrino dark matter

Physicists in the US have cast further doubt on whether a controversial neutrino is a potential candidate for dark matter — a mysterious substance that makes up nearly a quarter of the mass of the universe.

John Beacom (http://www.physics.ohio-state.edu/~beacom/) and Hasan Yuksel from Ohio State University and Casey Watson from Millikin University, Illinios have analysed data from the International Gamma-Ray Astrophysics Laboratory (INTEGRAL) satellite to rule out a range of possible mass values that "sterile" neutrinos, a candidate for dark matter, can take.

Neutrinos, which do not have an electric charge, currently come in three types or "flavours" — electron, muon and tau — that are each "active" meaning they interact via the nuclear weak force. Neutrinos also oscillate from one flavour to another as they travel, implying they have a mass.

In 1995, researchers based at the Liquid Scintillating Neutrino Detector (LSND) at Los Alamos looked at the oscillations between anti-muon and anti-electron neutrinos. To account for a discrepancy in the measured mass difference — a property that governs neutrino oscillation — they proposed a fourth, or "sterile" neutrino, which does not interact via the electroweak force and has a mass below about 1 eV.

Now you see them, now you don't

But last year an experiment at MiniBooNE at Fermilab, which was more sensitive than the LSND experiment, saw no evidence for these sterile neutrinos. However, dark matter also doesn't interact via any force except gravity. So the lack of interaction between sterile neutrinos and the three fundamental forces, bar gravity, means that higher mass sterile neutrinos — that weren't looked for in the MiniBooNE experiment — could be a potential candidate for dark matter.

Beacom and colleagues used a certain property of sterile neutrinos to detect their possible existence: that over the lifetime of the universe a tiny fraction of them decay and produce detectable X-rays (*Phys. Rev. Lett.* **101** 121301 (http://link.aps.org/abstract/PRL/v101/e121301)).

X-rays emitted by sterile neutrinos at a certain energy determine its mass while the flux of the X-rays determines the strength of the oscillation or so-called "mixing angle" — a parameter needed to fully characterize neutrino oscillations.

The researchers calculated the expected X-ray emission from the decay of sterile neutrinos in the Milky Way and compared it with the findings of the INTEGRAL satellite, which is sensitive to X-ray fluxes in the energy range of 20 keV and 8 MeV. INTEGRAL has a better energy resolution than previous satellites and allows physicists to better differentiate between X-rays concentrated at certain energies

from other astrophysical sources that produce X-rays over a broad energy range.

Search is far from over

Using their theoretical models and observations from INTEGRAL, Beacom and colleagues have now discounted the existence of sterile neutrinos with a mass between 40 keV and 1 MeV and with mixing angles between 10^{-14} to 10^{-6}. Though their finding means the search is far from over, "realistically, until someone, someday, finds a signal for dark matter, we will keep looking everywhere to test all possible candidates," says Beacom.

Next, Beacom and colleagues hope that further analysis of the data will allow even smaller masses and mixing angles for sterile neutrinos to be tested.

About the author

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