

KATRIN EXPERIMENT: SCIENCE & TECHNOLOGY

NEWS: Sensitive German experiment sets new limit on maximum neutrino mass

WHAT'S IN THE NEWS?

The Karlsruhe Tritium Neutrino (KATRIN) experiment has set a new upper limit of 0.45 eV for neutrino mass by directly studying tritium decay.

This breakthrough refines our understanding of neutrino properties and hints at physics beyond the Standard Model.

KATRIN Experiment: Estimating Neutrino Mass

- The Karlsruhe Tritium Neutrino Experiment (KATRIN), located in Germany, is a landmark project aimed at directly measuring the mass of neutrinos.
- In its latest result, it set a new upper limit of 0.45 electron volts (eV) for neutrino mass, improving over previous estimates.
- This is significant because the electron's mass is 511,000 eV, making the neutrino mass less than one-millionth of an electron's mass.
- The method involves studying beta decay of tritium (a radioactive isotope of hydrogen) and precisely measuring the energy of emitted electrons.
- KATRIN's findings are model-independent, unlike other methods such as cosmological studies or double beta decay which rely heavily on theoretical assumptions.

About Neutrinos

- Neutrinos are the most abundant elementary particles in the universe after photons.
- They belong to the lepton family and are electrically neutral (carry no charge).
- Despite being nearly massless, they are known to possess a tiny, non-zero mass — a discovery that altered the predictions of the Standard Model of particle physics.
- There are three known types (flavors): electron neutrino, muon neutrino, and tau neutrino.
- Neutrinos undergo a process called “oscillation” in which they change flavor as they travel — an effect that implies they have mass.
- Neutrinos travel close to the speed of light and interact only via the weak nuclear force and gravity, making them extremely difficult to detect.
- They are produced in:
 - Stellar fusion (e.g., in the Sun),
 - Nuclear reactors and particle accelerators,
 - Natural radioactive decay (e.g., potassium in bananas),
 - Cosmic-ray interactions in the atmosphere.

Importance of Measuring Neutrino Mass

- Helps answer fundamental questions about the imbalance between matter and antimatter.

- Provides insights into physics beyond the Standard Model.
- Affects models of the early universe and structure formation.
- May reveal new forces or interactions in nature.

Other Key Neutrino Experiments

- **PROSPECT & Fermilab SBN Program:** Study neutrinos from reactors and accelerators to detect hypothetical "sterile neutrinos."
- **MAJORANA Demonstrator:** Located deep underground, investigates whether neutrinos are their own antiparticles (Majorana particles).
- **NOvA & DUNE (Deep Underground Neutrino Experiment):** Investigate neutrino oscillations and mass hierarchy on a long-baseline scale.

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