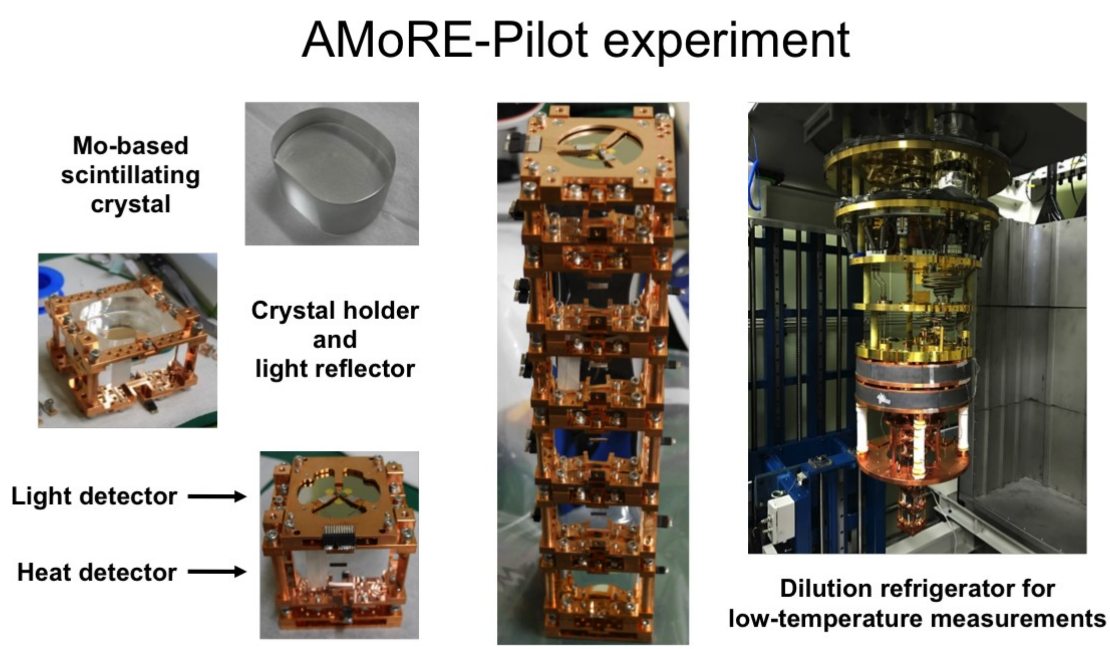
AMORE EXPERIMENT – SCIENCE & TECHNOLOGY

NEWS: The **AMoRE experiment in South Korea** has reported no evidence of **neutrinoless double beta decay (0vßß),** but its findings impose strict limits on this elusive subatomic process.

WHAT'S IN THE NEWS?

About the AMoRE Experiment

- **Full Name:** The AMoRE (Advanced Mo-based Rare Process Experiment) is an advanced international research initiative.
- **Objective:** Its primary goal is to detect **neutrinoless double beta decay (0νββ)**, a rare nuclear process that could reveal key properties of neutrinos.
- **Method:** The experiment uses **molybdenum-based crystals**, specifically enriched with the isotope Mo-100.
- **Cooling Technology:** These crystals are **cooled to near absolute zero** to reduce thermal noise and improve sensitivity.
- **Scientific Importance:** The experiment aims to determine whether **neutrinos are Majorana particles**, meaning particles that are their own anti-particles—a finding that could revolutionize particle physics.



Key Findings of the AMoRE Experiment

- **No Detection:** The AMoRE team did **not observe direct evidence** of neutrinoless double beta decay.
- **Strict Half-Life Limit:** It set a **lower bound on the half-life** of 0νββ in Mo-100 to be at least **10^{24} years**—an extraordinarily long time.
- **Neutrino Mass Constraint:** Based on the results, the **effective mass of neutrinos** is likely less than **0.22–0.65 billionths** (i.e., 0.22–0.65 eV) of a proton's mass.
- **Theoretical Implication:** Although the findings do not prove neutrinos are massless, they highlight a **significant gap in the Standard Model**, suggesting the presence of physics beyond it.

What Are Neutrinos?

- **Nature:** Neutrinos are **electrically neutral** and **nearly massless** subatomic particles.
- **Interaction:** They interact only through the **weak nuclear force** and **gravity**, which makes them extremely difficult to detect.
- **Abundance:** Neutrinos are among the **most abundant particles in the universe**, passing through matter almost undisturbed.
- **Scientific Mystery:** Due to their weak interactions and tiny mass, they remain **one of the most mysterious** particles in physics.

Understanding Beta Decay

- **Definition:** Beta decay is a type of **radioactive decay** where unstable nuclei transform to achieve a more stable state.
- **Forms of Beta Decay:**
    1. **Beta-minus decay (β^-):** A **neutron changes into a proton**, emitting an **electron** and an **anti-neutrino**.
    2. **Beta-plus decay (β^+):** A **proton transforms into a neutron**, releasing a **positron** and a **neutrino**.
    3. **Double beta decay:** Two neutrons convert into two protons **simultaneously**, emitting **two electrons** and **two anti-neutrinos**.

Neutrinoless Double Beta Decay (0νββ)

- **What Makes It Special:** In this rare process, **no anti-neutrinos are emitted**—only two electrons are released.
- **Possible Only If:** This process can happen **only if neutrinos are their own anti-particles** (i.e., Majorana particles).
- **Scientific Relevance:** Detecting 0νββ would indicate **lepton number violation**, a phenomenon not allowed in the Standard Model.

Significance of Detecting Neutrinoless Double Beta Decay (0νββ)

- **Confirm Particle Identity:** Would **prove that neutrinos are Majorana particles**.
- **Determine Mass Scale:** Help **accurately estimate the absolute mass** of neutrinos.
- **Challenge Existing Theories:** Would **contradict the Standard Model**, which assumes neutrinos are massless and do not violate lepton number conservation.

Key Terms Explained

- **Majorana Particle:** A particle that is **its own anti-particle**; unlike electrons or protons which have distinct anti-particles.
- **Beta Decay:** A **nuclear process** where unstable atoms transform by converting neutrons into protons or vice versa, releasing particles in the process.
- **Neutrinoless Double Beta Decay (0νββ):** A **hypothetical form of decay** where only electrons are emitted, implying neutrinos are Majorana particles.
- **Standard Model of Particle Physics:** The **current theoretical framework** describing all known fundamental particles and their interactions, **except gravity**.

Source: http://thehindu.com/sci-tech/science/new-finding-forces-search-for-ultra-rare-decay-process-to-continue/article69281791.ece