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A limit on neutrino mass with the first HOLMES dataset

The precise determination of the mass scale of (anti)neutrinos remains a fundamental open question in particle physics, carrying major implications ranging from sub-atomic physics to cosmological model.
The only model-independent approach to the measurement of neutrino mass is based on the analysis of the endpoint of beta or electron capture (EC) decay spectra, relying purely on kinematic constraints.
The spectrometric approach, which has historically been the cutting edge technology for these studies since 1970, is going to reach its sensitivity limit around 0.3 eV/c^2 due to technological constraints with the upcoming final DAQ campaign of the KATRIN experiment, which is currently setting the best upper limit on electron neutrino mass (m_ν < 0.45 eV @ 90% CL) by using a tritium source.
A promising strategy to circumvent this limit involves the adoption of a calorimetric technique, where the radioactive source is integrated directly into the detector. This configuration allows the measurement of all released energy except for that eventually carried away by the neutrino, thereby significantly reducing the systematic uncertainties.
The HOLMES experiment employs this approach, aiming to a sub-eV sensitivity on neutrino mass. It currently deploys arrays of Transition Edge Sensors based micro-calorimeters, embedded with ~0.5 Bq ^{163}Ho atoms and readout based on microwave SQUID multiplexing.
The EC decay of ^{163}Ho has been proposed as a channel for such a measurement due to its low Q-value (2.86 keV) and relatively short half-life (~4570 years). HOLMES employs arrays of 64x Ho-implanted micro-calorimeters, achieving an average energy and time resolutions of 6 eV (FWHM) and 1.5 μs, respectively.
HOLMES recently completed its first physics data-taking run, by collecting ~7×10^7 decay events over a two-month period. Analysis of the resulting spectrum led to a Bayesian upper limit on the effective electron neutrino mass of m⊠ < 27 eV/c^2 at 90% confidence level. Even if still far from the current best limit, this result proved the viability of ^{163}Ho calorimetry for future neutrino mass experiments and highlighted the potential of TES-based micro-calorimeters as a scalable and robust technology. Currently HOLMES is approaching a new experimental phase called HOLMES+, by developing larger arrays with increased single-pixel activity, enhancing statistical sensitivity and paving the way toward sub-eV measurements in the next decade.

Secondary track

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