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An independent reanalysis of the KATRIN bound on 3+1 active–sterile neutrino mixing

Light sterile neutrinos with masses of a few eV or larger have been proposed to explain the reactor and gallium anomalies. Their mixing with the electron neutrino would produce a characteristic kink in the tritium β-decay spectrum at $E \approx E_0 - m_4$, providing a test that is independent of reactor flux predictions. We present an independent reanalysis, in the $3+1$ scheme, of the integral spectrum measured by KATRIN in its first science run (KNM1), following the approach of Giunti, Li and Zhang. The differential spectrum is written as the incoherent superposition $(1-|U_{e4}|^2)R_\beta(E,m_\beta)+|U_{e4}|^2R_\beta(E,m_4)$, including the relativistic Fermi function and the molecular final-state distribution of T_2. It is then convolved with the published KATRIN response function. We build a χ^2 function in which the signal amplitude and background are profiled analytically, while the endpoint and m_β^2 are profiled numerically, including the systematic pull on m_β^2. The full analysis was implemented from scratch in Fortran and Python. The resulting exclusion curves in the $(\sin^2 2\vartheta_{ee}, \Delta m^2_{41})$ plane, from 90% to 99.73% CL, reproduce the main features of the published bounds. The best fit, $\sin^2 2\vartheta_{ee} \approx 0.04$ and $\Delta m^2_{41} \approx 220$ eV^2, is not statistically significant ($\Delta\chi^2 \approx 2.2$ relative to no mixing). We discuss the residual differences with the original analysis and the role of the final-state distribution, whose width mimics a negative m_β^2.

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