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Review of absolute neutrino mass measurements

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Neutrino flavor oscillation experiments have firmly established that neutrinos do have non-zero masses. This is a contradiction to the minimal Standard Model (SM) of Particle Physics. While being insensitive to the absolute neutrino mass scale, flavor oscillation experiments provide lower mass limits, depending on the neutrino mass ordering. Direct neutrino mass measurements establish upper limits and probe extensions of the SM employed to explain finite neutrino masses. Furthermore, comparison with neutrino masses extracted from cosmological observations can provide a non-trivial test of the Standard Model of Cosmology. The Mainz and Troitsk experiments established upper limits of $\leq 2\,\mathrm{eV/c^2}$ on the effective nuclear beta decay electron neutrino mass. The KATRIN experiment aims to reduce these limits down to $\leq 200\,\mathrm{meV/c^2}$ and will probe the quasi degenerate regime of neutrino mass ordering. I will review the current status of KATRIN and of fundamentally new laboratory approaches currently under development to either confirm a positive result independently or to push the sensitivity limit towards the $40\,\mathrm{meV/c^2}$ range, the lowest allowed electron neutrino mass under the inverted mass ordering. The new approaches (Project 8, ECHo, Holmes, …) uniquely combine new radioactive source concepts with novel schemes of decay electron spectroscopy to address the statistical and systematic challenges presented by this ambitious sensitivity goal. Major financial support by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics to the University of Washington under Award Number DE-FG02-97ER41020 is acknowledged.

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