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Final Results of GERDA on the Search for Neutrinoless Double-β Decay

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The search for neutrinoless double-beta decay is generally quoted as the only practical way to establish the nature of the mass of neutrino, one of the most elusive and intriguing elementary particles in the Standard Model. The detection of this rare nuclear decay would attribute to neutrino special properties, described for the first time by Ettore Majorana at the beginning of the last century. A discovery would decisively prove the inadequacy of current fundamental physics theories, in favor of more general formulations. According to some of these novel theories, it might even contribute to solve the mystery of the asymmetry between matter and anti-matter in our universe. For more than 50 years, neutrinoless double-beta decay has been unsuccessfully searched for in the germanium isotope with 76 nucleons.

The GERDA experiment, officially concluded in November 2019, has pioneered the technique of submerging enriched high-purity germanium detectors in liquid argon, at the underground Laboratori Nazionali del Gran Sasso (LNGS) in Italy. During its second experimental phase, GERDA has achieved a world-record background level in the region of interest of $5.2 \cdot 10^{-4}$ cts/(keV kg yr), making the $0\nu\beta\beta$ search effectively background-free. The collaboration has scrutinized 127.2 kg yr of exposure and found no evidence for for $0\nu\beta\beta$. This observation converts to a lower limit of $1.8 \cdot 10^{26}$ yr at 90% C.L., in terms of decay half-life –the most stringent ever set by a $0\nu\beta\beta$ experiment.

The GERDA collaboration has demonstrated the maturity of the germanium experimental technology to realize a background-free tonne-scale experiment with a target discovery sensitivity of 10^{28} yr on the $0\nu\beta\beta$ half-life. This is the ambitious goal of the LEGEND collaboration. The first phase of the experimental project, LEGEND-200, is currently being commissioned at LNGS and will start data taking by the end of this year.

Primary author: Dr PERTOLDI, Luigi (TU München, INFN Padova)

Presenter: Dr PERTOLDI, Luigi (TU München, INFN Padova)

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