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The future of double β decay research*

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The present status of neutrino physics makes it necessary to enhance the sensitivity of 2β decay experiments (in terms of the half-life limit for the $0\nu2\beta$ decay mode) to the level of 10^{26} – 10^{28} yr. By analyzing current results, the requirements for the future super-sensitivity projects are formulated as follows:

(i) The highest $0\nu2\beta$ limits were reached with the help of the "active" source technique (^{76}Ge, ^{116}Cd, ^{130}Te, ^{136}Xe), thus the future projects will belong to the same kind of technique because only in this case can the detection efficiency be close to 100%.

(ii) The best ^{76}Ge results were obtained by using $\approx$10 kg of enriched detectors. Hence, to reach the required sensitivity the enriched sources of hundreds kg have to be employed.

(iii) Because of the square root dependence of the sensitivity versus source mass, the background should also be reduced practically to zero.

(iv) The energy resolution is a crucial characteristic, and for the challenging projects the $FWHM$ value cannot be worse than $\approx$4% at $Q_{\beta\beta}$ energy.

(v) The measuring time of the future experiments will be of the order of $\approx$10 yr, hence detectors and set ups should be as simple as possible to provide stable and reliable operation during such a long period.

Such goals would certainly be reached in the next generation experiments like CAMEO, CUORE, EXO, MAJORANA, GEM, GENIUS, XMASS, etc.), where restrictions on the neutrino mass may be advanced to the level of $m_\nu \leq$ 0.01 eV.

For example, Monte Carlo simulations and pilot measurements with ^{116}Cd show that sensitivity of the CAMEO experiment is $\approx 10^{26}$ yr with $\approx$100 kg of enriched $^{116}CdWO_4$ crystals placed in the liquid scintillator of the BOREXINO CTF. This value corresponds to a bound on the neutrino mass of $m_\nu \leq 0.06$ eV.

To advance these results further the GEM, GENIUS and MAJORANA experiments are designed for the 2β decay study of ^{76}Ge. In particular, in the GEM set up about one ton of "naked" HP Ge detectors (natural or enriched in ^{76}Ge to 86%) are operating in super-high purity liquid nitrogen contained in the Cu vacuum cryostat. The latter is placed in the one kt water shield. The sensitivity of the GEM is $\approx 10^{27}$ yr with natural Ge crystals and $\approx 10^{28}$ yr with enriched ones, which translate to the restrictions on the neutrino mass $m_\nu \leq 0.05$ eV and $m_\nu \leq 0.015$ eV for natural and enriched detectors, respectively.

In addition, the GEM, GENIUS, XMASS and other projects may advance the best current limits on the existence of neutralinos – as dark matter candidates – by two-three orders of magnitude, and at the same time would be able to identify unambiguously the dark matter signal by detection of its seasonal modulation. All of these results will provide crucial tests of the key theoretical models of modern astroparticle physics and cosmology.

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