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On the possibility to search for 2β decay of initially unstable (α/β radioactive) nuclei

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Abstract. – An alternative method to search for 2β decay is discussed. Contrary to the "conventional" approach (where only β stable 2β candidates are used), it is intended to study α/β unstable nuclei, whose 2β energy release, $Q_{\beta\beta}$, is much higher in most of the cases than that of "conventional" 2β candidates. As an example, the first experimental half-life limits on 2β decay of radioactive nuclides from U and Th families (contaminants of the $CaWO_4$ and $CdWO_4$ scintillators) were set by reanalyzing the data of low-background measurements in the Solotvina Underground Laboratory (1734 h with $CaWO_4$ and 13316 h with $CdWO_4$).

Introduction. – Despite numerous efforts, the neutrinoless (0ν) double β decay still remains unobserved, and only half-life limits were established up-to-date in direct experiments with many nuclides (see reviews [1–4]). The best published bounds are: $T^{0\nu}_{1/2} \geq 10^{22}$ y for ^{48}Ca [5], ^{82}Se [6], ^{100}Mo [7]; $T^{0\nu}_{1/2} \geq 10^{23}$ y for ^{116}Cd [8], ^{128}Te, ^{130}Te [9], ^{136}Xe [10]; and $T^{0\nu}_{1/2} \geq 10^{25}$ y for ^{76}Ge [11,12]. These results have already brought the most stringent restrictions on the values of the Majorana neutrino mass $m_\nu \leq 0.2$–2 eV, the right-handed admixtures in the weak interaction $\eta \approx 10^{-8}$, $\lambda \approx 10^{-6}$, the neutrino-Majoron coupling constant $g_{\mathrm{M}} \approx 10^{-4}$, and the R-parity violating parameter of minimal supersymmetric standard model $\approx 10^{-4}$ [1–4]. Moreover, recent observations of neutrino oscillations, strongly suggesting that neutrinos have nonzero mass, provide important motivation for the 2β decay experiments. Indeed, the $0\nu 2\beta$ decay —forbidden in the standard model (SM) of electroweak theory since it violates lepton number (L) conservation— requires neutrinos to be massive Majorana particles. At the same time, many extensions of the SM incorporate L violating interactions and, thus, could lead to this process, which, if observed, will be a clear evidence for a new physics beyond the SM and a unique confirmation of the Majorana nature of the neutrino. Because oscillation experiments are sensitive to the neutrino mass difference, only the measured $0\nu 2\beta$ decay rate can give the absolute scale of the effective Majorana neutrino mass and, consequently, could test different neutrino mixing models [13].

However, the $0\nu 2\beta$ decay could be firmly *discovered* only in case that the present sensitivity were enhanced by several orders of magnitude to $m_\nu \approx 0.01$ eV [13]. It is a great experimental challenge, and several ambitious 2β projects were proposed recently aiming to reach this goal [1–3]. These projects intend to use up to tons of superlow-background detectors (made of enriched 2β isotopes), which should run for many years. Nevertheless, there is

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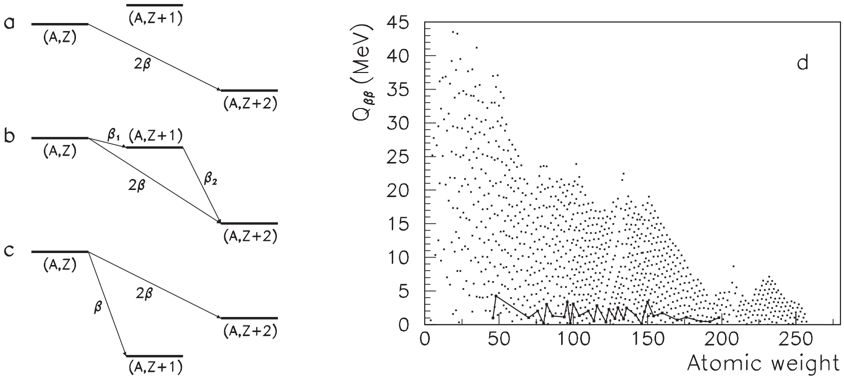

Fig. 1 – (a-c) Different configurations of (A, Z)-$(A, Z + 1)$-$(A, Z + 2)$ triplet: (a) "conventional" $2\beta^-$ case when the atomic mass of the intermediate nuclide $(A, Z + 1)$ is larger than that of (A, Z) and $(A, Z+2)$ nuclei, and thus, the ordinary β^- decay of (A, Z) is forbidden; (b) and (c) "unconventional" configurations when 2β decay is one of the branches of (A, Z) decay. (d) Energy release in $2\beta^-$ decays. $Q_{\beta\beta}$ values for "conventional" nuclides are shown in bold and connected by a line. Similar pictures can be drawn also for $2\beta^+$ decay.

a chance that the required advancement of the sensitivity could be beyond reach of current technologies applied within the framework of "conventional" methods. Hence, investigation of other experimental approaches and discussion of some new and even unusual ideas could be fruitful for the future 2β decay research.

In the process of $2\beta^-$ decay (see fig. 1) two electrons are emitted simultaneously; thus, an initial nucleus (A, Z) is transformed to $(A, Z + 2)$, which is, in principle, possible if the atomic mass of initial isotope $M(A, Z)$ is larger than the mass of the final one $M(A, Z+2)$. In practice, 2β decay can be observed if, in addition to this requirement, an ordinary β decay of the nucleus (A, Z) to the $(A, Z + 1)$ is forbidden energetically, or if such a decay is suppressed by a large difference in spin between these nuclei. However, an additional demand is not mandatory —it just specifies the condition, which makes 2β decay study convenient, because, otherwise, it would be very difficult to distinguish 2β decays from the intensive β background. To this effect, only "conventional" 2β decay candidate nuclei, satisfying both demands, were studied in direct experiments until now [1–4].

In the present paper we are going to demonstrate that investigation of the 2β decay of initially unstable (β or/and α) nuclei (see fig. 1b and c) could be interesting too [4]. With this aim, let us remember that the probability of the $0\nu2\beta$ decay strongly depends on the $Q_{\beta\beta}$ value, roughly as $Q^5_{\beta\beta}$ [14]. It means that the sensitivity of a 2β experiment to the neutrino mass bound, which could be derived from the experimental half-life limit, $T^{\mathrm{exp}}_{1/2}$, is proportional to $Q^{-5/2}_{\beta\beta}$. Hence, the larger is the $Q_{\beta\beta}$ value, the more stringent m_ν restriction could be derived. Note that for any of 69 "conventional" $2\beta^\pm$ decay candidate nuclei [4] their 2β energy releases do not exceed $\approx 4.3\,\mathrm{MeV}$, while for many of "unconventional" $2\beta^\pm$ nuclides the $Q_{\beta\beta}$ values are larger up to ten times [15] (see fig. 1d). For example, $Q_{\beta\beta}$ for ^{19}B (or ^{22}C) is $\approx 43\,\mathrm{MeV}$, therefore its $0\nu2\beta$ decay rate would be $\approx 4 \times 10^6$ times faster than that for ^{76}Ge with $Q_{\beta\beta} \approx 2\,\mathrm{MeV}$.

Regarding practical schemes of 2β experiments involving "unconventional" candidates, two more or less realistic methods could be suggested:

TABLE I – *Some nuclides in* U/Th *radioactive chains, which could undergo* $2\beta^-$ *decay, and half-life limits determined in this work with the* ^{116}CdWO$_4$ *(for* ^{232}Th*) and* CaWO$_4$ *(for other isotopes) detectors. Only the* 2β *decay half-life of* ^{238}U *(all modes) was previously measured in radiochemical experiment as* $T^{2\beta}_{1/2} = (2.0 \pm 0.6) \times 10^{21}$ y [16].

Parent nuclide	Main decay channel	$T^{\alpha/\beta}_{1/2}$	$Q_{\beta\beta}$, MeV	$\lim T^{2\beta}_{1/2}$ at 68% C.L. for $0\nu(2\nu)$ mode
$^{232}_{90}$Th	α	1.405×10^{10} y	0.842	1.6×10^{11} (2.1×10^{9}) y
$^{238}_{92}$U	α	4.468×10^{9} y	1.147	1.0×10^{12} (8.1×10^{10}) y
$^{234}_{90}$Th	β^-	24.10 d	2.470	144 (2.5) y
$^{226}_{88}$Ra	$\alpha +^{14}_{6}$ C	1600 y	0.476	4.1×10^{4} (4.5×10^{3}) y
$^{222}_{86}$Rn	α	3.8235 d	2.057	2.8 (0.11) y
$^{210}_{82}$Pb	$\beta^- + \alpha$	22.3 y	1.226	1.2×10^{5} (8.6×10^{3}) y

1) Use of artificial unstable nuclides produced with accelerators or reactors(¹). Current possibilities to create radioactive ion beams with accelerators and to accumulate them in storage rings are at the level of 10^{19} nuclei per year [17]. Concerning reactor-produced isotopes, such an approach has been already used in the radiochemical search for 2β decay of ^{244}Pu, in which the limit (on all 2β modes) was set at $T_{1/2} \geq 1.1 \times 10^{18}$ y [18].

2) Use of appropriate unstable nuclides in natural radioactive U/Th chains, which are present, as contamination, in any materials, even in the low-background detectors. Thus, limits on 2β decays of such "unconventional" isotopes can be derived as by-product of any low-background measurements with the proper detector (including searches for "conventional" 2β decay).

To make a choice of a candidate for study, let us consider the experimental sensitivity of the approach 2). For the radioactive chain in equilibrium, decay rates of different isotopes, $R^{\alpha/\beta} = \mathrm{d}N/\mathrm{d}t$, are the same. The number of nuclei N for each isotope can be determined as $N = R^{\alpha/\beta} \cdot T^{\alpha/\beta}_{1/2}/\ln 2$. Here $T^{\alpha/\beta}_{1/2}$ is the isotope's half-life for the usual α or β decay (small contribution from 2β decay is neglected). On the other hand, the half-life limit on 2β decay is equal: $\lim T^{2\beta}_{1/2} = \varepsilon \cdot \ln 2 \cdot N \cdot t/\lim S$, where ε is the efficiency to detect the 2β process, t is the time of measurements, and $\lim S$ is the number of 2β events which can be excluded with a given confidence level on the basis of experimental data. Combining these two equations and expressing the $\alpha(\beta)$ decay rate $R^{\alpha/\beta}$ through the observed specific activity $A^{\alpha/\beta} = R^{\alpha/\beta}/m$ (m is the detector mass), one can get finally:

$$\lim T^{2\beta}_{1/2} = \varepsilon \cdot m \cdot t \cdot A^{\alpha/\beta} \cdot T^{\alpha/\beta}_{1/2}/\lim S. \tag{1}$$

From the latter one can see that the larger is $T^{\alpha/\beta}_{1/2}$, the higher $T^{2\beta}_{1/2}$ limit could be established. To obtain nontrivial bound $\lim T^{2\beta}_{1/2} > T^{\alpha/\beta}_{1/2}$, the condition $\varepsilon \cdot m \cdot t \cdot A^{\alpha/\beta}/\lim S > 1$ should be fulfilled. For typical values of $\varepsilon \approx 1$ (if the 2β decaying isotope is contained in the detector itself), one year of measurements, $\lim S = 2.4$ counts (*i.e.*, for zero observed 2β events [19]), $m = 10$ kg, and $A^{\alpha/\beta} = 1\ \mu$Bq/kg (so, for quite low contamination of detector by U/Th chains), we obtain the ratio $\lim T^{2\beta}_{1/2}/T^{\alpha/\beta}_{1/2} \approx 100$. For the higher level of contamination $A^{\alpha/\beta} = 1$ mBq/kg, this ratio is equal to 10^5. In conclusion, to reach higher sensitivity, one has to select the candidate nuclides with the largest $Q_{\beta\beta}$ energies and with the longest $T^{\alpha/\beta}_{1/2}$ values. In table I

(¹)In addition, such nuclides (but in much less quantities) could be produced in detector by cosmic rays.

properties of some potentially 2β decaying nuclei in U/Th families are summarized [20]. As an example, we report below the first experimental results of the search for 2β decays of unstable nuclides in U/Th chains performed in the real-time measurements with the low-background $CaWO_4$ and $CdWO_4$ crystal scintillators, which contain these nuclides as contaminations.

Experiments and data analysis. – The experiments were carried out in the Solotvina Underground Laboratory of INR in a salt mine 430 m underground ($\simeq 1000$ mwe, with a cosmic muon flux of $1.7 \times 10^{-6}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$, a neutron flux $\leq 2.7 \times 10^{-6}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$, and a radon concentration in the air $< 30\,\mathrm{Bq\,m}^{-3}$) [8]. The total exposure was equal to 1734 h with $CaWO_4$ (13316 h with $CdWO_4$) detector. Since detailed descriptions of the apparatus and measurements with the $CdWO_4$ detector are given in refs. [8], we will describe only main features, performances and experimental procedure used with the $CaWO_4$ crystal scintillator [21].

The $CaWO_4$ crystal (dimensions $40 \times 34 \times 23$ mm) has mass of 189 g. Its measured light output (peak emission at 440 nm with decay time of $\approx 8\,\mu$s) is $\approx 16\%$ as compared with that of NaI(Tl). The crystal was viewed by the special low-radioactive $5''$ photomultiplier tube (EMI D724KFLB) through the quartz light-guide $\oslash 10 \times 33$ cm. The detector was surrounded by a passive shield made of teflon (thickness of 3–5 cm), plexiglass (6–13 cm), high-purity copper (3–6 cm), lead (15 cm) and polyethylene (8 cm). Two plastic scintillators ($120 \times 130 \times 3$ cm) installed above the passive shield were used as a cosmic μ veto. Event-by-event data acquisition records information on the amplitude (energy), arrival time and pulse shape of a signal. For the latter, a transient digitizer based on the fast 12 bit ADC was used with the sample frequency of 20×10^6 samples/s [22]. Events in the chosen energy interval were recorded in 2048 channels with 50 ns channel's width. The linearity of the energy scale and resolution of the detector were measured with ^{60}Co, ^{137}Cs, ^{207}Bi, ^{232}Th and ^{241}Am γ sources in the energy interval of 60–2615 keV. The FWHM can be fitted by the function: $\mathrm{FWHM}_\gamma\,(\mathrm{keV}) = -3 + \sqrt{6.9E_\gamma}$, where E_γ is the energy of γ quanta in keV. For example, FWHM is equal to 9.7% at the energy 662 keV. The routine calibrations were carried out weekly with ^{207}Bi and ^{232}Th sources. The α/β ratio of the crystal was measured with the help of collimated α particles (^{241}Am) in the range of 0.5–5.3 MeV by using the set of thin mylar films. Besides, α peaks of ^{147}Sm and nuclides from the ^{232}Th, ^{235}U and ^{238}U families, present as trace in the $CaWO_4$ crystal, were used to extend the energy interval up to $\simeq 8$ MeV. Alpha peaks of ^{147}Sm, ^{210}Po, ^{218}Po, ^{232}Th, ^{238}U were selected with the help of a pulse-shape analysis (see below), while ^{214}Po, ^{215}Po, ^{216}Po, ^{219}Rn and ^{220}Rn peaks were reconstructed with the help of a time-amplitude analysis from the data accumulated in the low-background measurements. In the energy interval 0.5–2 MeV, the α/β ratio decreases with energy: $\alpha/\beta = 0.21(3)$–$0.020(15)E_\alpha$, while it increases in the interval of 2–5 MeV: $\alpha/\beta = 0.129(12) + 0.021(3)E_\alpha$, where E_α is in MeV [21].

The pulse shape of $CaWO_4$ scintillation signals is slightly different for events produced by α particles and γ quanta (or β particles) [21]. This difference allows us to discriminate $\gamma(\beta)$ events from those of α particles by using the method of the optimal digital filter, which previously was successfully applied with $CdWO_4$ scintillators [22]. To obtain the numerical characteristic of the $CaWO_4$ signal, the so-called shape indicator (SI), each experimental pulse $f(t)$ was processed with the following digital filter: $SI = \sum f(t_k) \times P(t_k) / \sum f(t_k)$, where the sum is over time channels k, starting from the origin of the pulse and up to $75\,\mu$s, $f(t_k)$ is the digitized amplitude (at the time t_k) of a given signal. The weight function $P(t)$ is defined as $P(t) = \{\overline{f}_\alpha(t) - \overline{f}_\gamma(t)\}/\{\overline{f}_\alpha(t) + \overline{f}_\gamma(t)\}$, where $\overline{f}_\alpha(t)$ and $\overline{f}_\gamma(t)$ are the reference pulse shapes for α particles and γ quanta, resulting from the average of a large number of experimental pulse shapes. As a result, the distinct discrimination between α particles and γ rays (β particles) was achieved allowing us to clearly separate α events from U/Th chains and $\gamma(\beta)$ events in the background data, accumulated with the $CaWO_4$ detector [21].

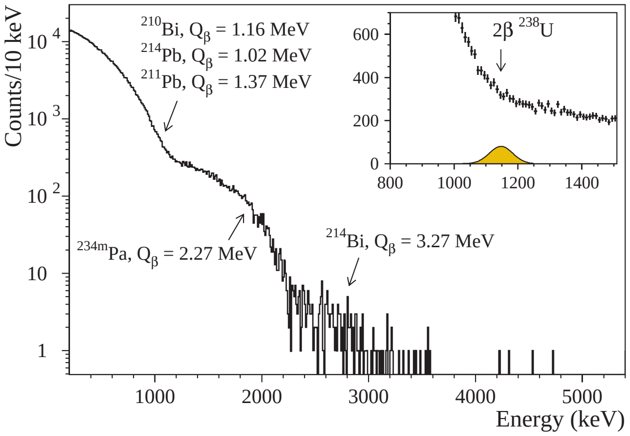

Fig. 2 – Energy spectrum of $\beta(\gamma)$ events selected by the pulse-shape analysis from background data measured with the $CaWO_4$ detector (0.189 kg, 1734 h). It is described by β spectra of ^{210}Bi ($Q_\beta =$ 1.16 MeV), ^{214}Pb ($Q_\beta = 1.02$ MeV), ^{211}Pb ($Q_\beta = 1.37$ MeV), ^{234m}Pa ($Q_\beta = 2.27$ MeV), and ^{214}Bi ($Q_\beta = 3.27$ MeV). Inset: the energy region of the $0\nu2\beta$ decay of ^{238}U is shown together with the expected peak of $0\nu2\beta$ decay which corresponds to $T_{1/2} = 10^{11}$ y.

The energy spectrum of the $CaWO_4$ detector (measured during 1734 h) was separated into α and β spectra with the help of the pulse-shape discrimination technique. First, the α spectrum has been analyzed [21]. The intensive and clear peak at the energy 1.28 MeV (in γ scale) has been attributed to intrinsic ^{210}Po (daughter of ^{210}Pb from the ^{238}U family) with activity of 0.291(5) Bq/kg, while the peak at ≈ 0.8 MeV has been attributed to ^{232}Th with activity of 0.69(10) mBq/kg. The total internal alpha activity in the crystal is ≈ 0.4 Bq/kg. Secondly, the raw data were analyzed by the time-amplitude method, when the energy and arrival time of each event were used for selection of some decay chains in ^{232}Th, ^{235}U and ^{238}U families. For instance, the following sequence of α decays from the ^{232}Th family was searched for and observed: ^{220}Rn ($Q_\alpha = 6.40$ MeV, $T_{1/2} = 55.6$ s) $\rightarrow$ ^{216}Po ($Q_\alpha = 6.91$ MeV, $T_{1/2} = 0.145$ s) $\rightarrow$ ^{212}Pb (which are in equilibrium with ^{228}Th). Because the energy of α particles from ^{220}Rn decay corresponds to $\simeq 1.6$ MeV in γ scale of the $CaWO_4$ detector, the events in the energy region 1.4–2.2 MeV were used as triggers. Then, all events (1.4–2.2 MeV) following the triggers in the time interval 20–600 ms (containing 85.2% of ^{216}Po decays) were selected. On this basis, the activity of ^{228}Th in the $CaWO_4$ crystal was calculated as 0.6(2) mBq/kg, which is in good agreement with the activity of ^{232}Th determined from α spectrum: 0.69(10) mBq/kg. Besides, the following sequence of β and α decays from the ^{226}Ra chain was used: ^{214}Bi ($Q_\beta = 3.27$ MeV) $\rightarrow$ ^{214}Po ($Q_\alpha = 7.83$ MeV, $T_{1/2} = 164\,\mu$s) $\rightarrow$ ^{210}Pb. The obtained ^{214}Bi and ^{214}Po spectra lead to the ^{226}Ra activity in the $CaWO_4$ crystal equal to 5.6(5) mBq/kg.

Finally, the energy spectrum of $\beta(\gamma)$ events, selected with the help of the pulse-shape technique and presented in fig. 2, has been analyzed [21]. The counting rate above 0.2 MeV is ≈ 0.45 counts/(s $\cdot$ kg). The contribution of the external γ-rays to this background rate was estimated as $\approx 2\%$, by using results of measurements with the $CdWO_4$ crystal (mass of 0.448 kg) installed in the same low-background set-up. The remaining $\beta(\gamma)$ events are caused by the intrinsic contaminations of the $CaWO_4$ crystal. The major part of this β activity can be ascribed to ^{210}Bi (daughter of ^{210}Pb): 0.291 Bq/kg; ^{234m} Pa: 0.014 Bq/kg; ^{214}Pb and ^{214}Bi (^{238}U family): ≈ 0.007 Bq/kg; ^{211}Pb (^{235}U family): ≈ 0.002 Bq/kg. The remaining β events can be explained by other β active impurities (^{40}K, ^{90}Sr in equilibrium with ^{90}Y, ^{137}Cs, etc.) probably present in the crystal. One can conclude that radioactive impurities in the $CaWO_4$ crystal (available at present) are much higher (by factor of 10–10^3) than those of the $CdWO_4$ scintillator [8, 21].

Limits on 2β decay and conclusions. – The background spectra of β/γ events measured (and selected by the pulse-shape discrimination method) with the $CaWO_4$ and $CdWO_4$ scintillators were analyzed to search for 2β decays of unstable isotopes in U/Th chains. In general, we did not find any peculiarities in the measured spectra which can be attributed to the 2β decays searched for. Therefore, only lower half-life limits were established in accordance with eq. (1). Values of $\lim S$ were simply estimated as a square root of the number of counts in the corresponding energy windows of the background spectra. For instance, in the spectrum measured with the $CaWO_4$ detector, there are 3937 counts in the energy interval 1110–1200 keV where the peak of the $0\nu2\beta$ decay of ^{238}U is expected. The number of ^{238}U nuclei is $N = 5.4 \times 10^{14}$, and the detection efficiency in this energy region is $\varepsilon = 0.85$. The $\lim S = 63$ counts and the measurement time $t = 1734$ h lead to the restriction on the half-life: $T_{1/2}^{0\nu} \geq 1.0 \times 10^{12}$ y at 68% C.L. In the inset of fig. 2, the $CaWO_4$ spectrum in the energy window of the $0\nu2\beta$ decay of ^{238}U is shown together with the $0\nu2\beta$ decay peak corresponding to $T_{1/2} = 10^{11}$ y. Considering the energy interval 200–760 keV (number of background counts is 4.7×10^5, efficiency $\varepsilon = 0.75$), the half-life limit on the two-neutrino 2β decay of ^{238}U was estimated as $T_{1/2}^{2\nu} \geq 8.1 \times 10^{10}$ y at 68% C.L.

Similarly, such a procedure was applied to estimate $T_{1/2}$ limits for 2β decays of other nuclides in U/Th radioactive chains in the $CaWO_4$ crystal, and by using data accumulated with the $^{116}CdWO_4$ detector [8]. All results are summarized in table I, from which it is clear that half-life limits derived in this first attempt are much more modest than those obtained in "conventional" 2β decay experiments. Obviously, the sensitivity of the proposed method could be further enhanced by producing scintillators loaded by thorium or uranium (the level of allowed concentration of these nuclides is restricted by the requirement of reasonable counting rate and by demand to keep satisfactory scintillation characteristics of a detector). For example, supposing the use of the fast scintillator (with decay time in the range of ns), the activity of the U/Th admixture could be increased to $\simeq 10^4$ Bq/kg in comparison with the current level of ~ 1 mBq/kg. Together with the total mass of detectors enlarged from $\simeq 0.1$ kg to 100 kg, it could allow one to advance the current limits on 2β half-lives of nuclides in U/Th chains by several orders of magnitude, which looks interesting.

Let us consider also the unstable nuclides, which can be produced with accelerators or reactors for the 2β decay searches. There exist plans of large-scale experiments with beams of β decaying radioactive ions, which produce intensive beams of pure ν_e and $\tilde{\nu}_e$, for high-precision measurements of neutrino oscillations [17]. In principle, these experiments could also give, as by-product, results on the $0\nu2\beta$ decay of the involved nuclei. Unfortunately, even preliminary schemes for the extraction of such by-products were not debated yet. However, as an inspiring example, we can mention the experiment [23], where α active ^{221}Ra isotope with $T_{1/2} = 28$ s was produced by bombarding a thorium target with the 600 MeV proton beam. Then, the cluster radioactivity of ^{221}Ra (emission of ^{14}C) was observed with $T_{1/2} = 7.8 \times 10^5$ y [23], that is $\approx 10^{12}$ times longer than the half-life of ^{221}Ra alpha decay.

In addition, by analyzing the table of isotopes [20] for the long-lived unstable nuclei (with $T_{1/2} > 1$ y), which can simultaneously undergo 2β decay, we have found three nuclides with $Q_{\beta\beta}$ values higher than 4 MeV: ^{42}Ar ($T_{1/2} = 32.9$ y, $Q_{\beta\beta} = 4125$ keV), ^{126}Sn ($T_{1/2} \simeq 1 \times 10^5$ y, $Q_{\beta\beta} = 4050$ keV) and ^{208}Po ($T_{1/2} = 2.9$ y, $Q_{\mathrm{ECEC}} = 4280$ keV). Among them, ^{126}Sn seems to be the most interesting one due to its longest lifetime. As a possible detector for the

$0\nu2\beta$ decay search of ^{126}Sn, the liquid scintillator loaded by ^{126}Sn could be considered. The contribution of two successive single β decays $^{126}_{50}$Sn ($T_{1/2} \simeq 1 \times 10^5$ y, $Q_\beta = 380$ keV) $\rightarrow$ $^{126}_{51}$Sb ($T_{1/2} = 12.5$ d, $Q_\beta = 3670$ keV) $\rightarrow$ $^{126}_{52}$Te to the background in the energy window of the $0\nu2\beta$ decay of ^{126}Sn would be negligible due to the long half-life of the intermediate ^{126}Sb nucleus and taking into account the energy distributions of both (^{126}Sn and ^{126}Sb) β spectra. We recall that there is only one "convenient" 2β candidate with $Q_{\beta\beta} > 4$ MeV: ^{48}Ca, whose natural abundance is very low (0.187%) which makes the production of the enriched ^{48}Ca isotope very expensive. Note that for equal experimental $T_{1/2}$ limits on $0\nu2\beta$ decay, the ^{126}Sn bound would be more sensitive to the neutrino mass than that of ^{48}Ca due to the larger phase space available for ^{126}Sn (the latter depends not only on the $Q_{\beta\beta}$ but on the Z value of a nucleus as well). Unfortunately, present perspectives to obtain considerable amounts of ^{126}Sn isotope are unclear too.

Nevertheless, we believe that in the light of the present-day status of the 2β decay research, it is useful to discuss and test some "unconventional" ideas and approaches to detect the $0\nu2\beta$ decay, like that presented in this paper, even notwithstanding the modest experimental limits reached for the first time and quite uncertain perspectives of their advancement from the to-date point of view.

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