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Search for nucleon decays into invisible channels with the BOREXINO Counting Test Facility

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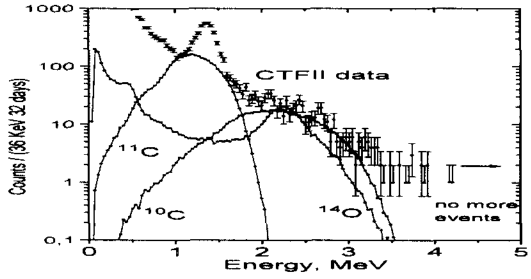
Experimental searches for nucleon instability were devoted mainly to decays of nucleons to strongly or electromagnetically interacting particles. At the same time, for modes where a nucleon or a pair of nucleons disappears or decays to some weakly interacting particles (neutrinos, majorons, etc.), the experimental bounds are few orders of magnitude lower.

In the present work we study the radioactive decay of daughters (time-resolved from prompt products), created as a result of N or NN decays of mother nuclei, incorporated into the low-background detector - the Counting Test Facility, prototype of BOREXINO detector (see [1]).

Calculated responses for the decay of ^{11}C and ^{10}C in the liquid scintillator (created after n and nn decay or disappearance in ^{12}C) and ^{14}O in the water shield (nn decay in ^{16}O) are shown in fig.1. To extract limits on the life time, it was assumed very conservatively that *all* events in the CTF experimental spectrum in the corresponding energy range ΔE are due to nucleon decays.



The p (or pp) decays in ^{13}C will result in ^{12}B (or ^{11}Be) nuclei, β^- decaying with high energy release Q = 13.370 MeV (or 11.508 MeV). To estimate the $\tau_{\lim}$ for p and pp instabilities, we use the fact that no events were observed in the CTF spectrum with energies higher than 4.5 MeV.

Using the unique features of the BOREXINO Counting Test Facility – the super-low background, large mass of 4.2 tons and low energy threshold – the new limits on N and NN decays into *invisible* channels (disappearance, decays to neutrinos, majorons, etc.) have been set (see table, all limits for 90% c.l.).

	Decay	N_{nucl}	N_{obj}	$\tau_{\lim}$, yr
p	${}^{13}_{6}\mathrm{C}\rightarrow{}^{12}_{5}\mathrm{B}$	$2.0{\cdot}10^{27}$	4	$1.2 \cdot 10^{26}$
n	${}^{12}_{6}\mathrm{C}\rightarrow{}^{11}_{6}\mathrm{C}$	$1.9{\cdot}10^{29}$	4	$3.1 \cdot 10^{25}$
nn	${}^{12}_{6}\mathrm{C}\rightarrow{}^{10}_{6}\mathrm{C}$	$1.9{\cdot}10^{29}$	2	$3.9 \cdot 10^{25}$
	${}^{16}_{8}\mathrm{O}\rightarrow{}^{14}_{8}\mathrm{O}$	$9.8{\cdot}10^{29}$	1	$5.5 \cdot 10^{24}$
pp	${}^{13}_{6}\mathrm{C}\rightarrow{}^{11}_{4}\mathrm{Be}$	$2.0{\cdot}10^{27}$	2	$5.5 \cdot 10^{25}$

The established limits are better (from few times to two orders of magnitude) than those determined in a similar approach in [2]. The result for p decay into *invisible* is competitive, and bounds for nn and pp decays are the best up-to-date limits set in all other approaches, including radiochemical and geochemical experiments.

References

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