SEARCH FOR β-DELAYED THREE-NEUTRON EMISSION FROM ^{31}Na

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Abstract

An upper limit $P_{3n} < 5 \times 10^{-4}$ is found for the branching ratio of the β-delayed three-neutron emission from ^{31}Na.

For very neutron rich isotopes, β-delayed two-neutron emission has been shown to be an important decay mode [1]. But a possibility also exists of observing β-delayed three-neutron emission since $Q_\beta - B_{3n}$ can become positive. For instance, a 11.62 ± .22 MeV mass value [2] of ^{31}Na leads to $Q_\beta - B_{3n} = 2.35 \pm .22$ MeV.

In view of the strong ^{31}Na yield from high-energy fragmentation reaction, and of the high sensitivity provided by the long half-life of the expected ^{28}Mg product, ^{31}Na was felt to be an ideal candidate for the observation of the admittedly very small β-delayed three-neutron decay mode.

The ^{31}Na isotopes are produced in the fragmentation of Iridium by 24 GeV protons from the CERN synchrotron. They are analyzed by an on-line mass spectrometer [3]. We obtain a typical yield of some 2×10^4 $^{31}Na^+$ ions diffusing within a few tens of ms from the ion source after each beam burst, e.g. every 3 seconds.

If ^{31}Na decays to a level of ^{31}Mg energeticaly unstable to 3n emission, and if this decay channel is preferred to one - or two-neutron emission, the 21.1 hour of ^{28}Mg product nucleus accumulates in the collecting foil. This catcher has the shape of a deep test tube so that the ^{28}Mg nucleus which can recoil out of the foil from three-neutron emission is reimplanted into it. After collecting ^{31}Na ions during one day or so, a search is made for the characteristic activity of ^{28}Mg. This method was already successfuly used to measure the β-delayed two-neutron branching ratio P_{2n} of ^{30}Na[1]. In the present case, the sensitivity of the method was improved by requesting that the γ-ray observed be in coincidence with a β-particle. In this way the background count rate was reduced to 3×10^{-2} per keV and per hour in the energy spectrum in the vicinity of the 1779 keV γ-ray from ^{28}Mg.

No γ activity was observed above the background level from the collecting foil. This corresponds to an upper limit for β-delayed three-neutron emission, $P_{3n} < 5 \times 10^{-4}$.

This limit is of the order of the branching ratio expected from E_β dependance alone since P_{2n} was found [1] to be 7×10^{-3} for $Q_\beta - B_{2n} = 6.2$ MeV. However, an estimate of $P_{3n}(^{31}Na)$, calculated by Takahashi[4] in the framework of the gross theory of β decay, predicts an extremely small P_{3n} value, 7×10^{-7}, since most of the strength above the $^{31}Mg \rightarrow {}^{28}Mg + 3n$ threshold decays by emission of one or two neutrons only.

It is impossible at this stage to significantly improve the ^{31}Na yield, hence to lower the present limit on P_{3n}. Therefore the somewhat exceptional ^{11}Li nucleus will remain the only known case of β-delayed three-neutron emission[5].

The authors are grateful to Dr. K. Takahashi for his interest and comments.

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4) K. Takahashi, private communication

5) R.E. Azuma et al. Phys. Lett. 96B (1980) 31
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