A STUDY OF LIGHT NEUTRON-RICH NUCLEI BY TWO-BODY NUCLEAR REACTIONS

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Abstract

^{14}C or ^{18}O-induced two-body nuclear reactions are used to measure the mass excess and in some cases the excited state energies of ^{14}B, ^{18}C, ^{18}N and ^{19}N. Upper limits only are obtained for the cross sections of the (^{14}C, ^{14}Be) and (^{18}O, ^{22}O) reactions.

1 - Introduction

Charge-exchange, double charge exchange and complex rearrangement reactions induced by the ^{14}C and ^{18}O beams from the Orsay MP-Tandem have been used to produce the neutron-rich nuclei ^{14}Be, ^{14}B, ^{18}C, ^{18}N, ^{19}N and ^{22}O. For each of the two-body reactions studied, we tried to observe the exotic nucleus itself with an experimental method which is described in detail elsewhere[1,2,3,4].

2 - ^{14}Be

The reaction $^{48}Ca(^{14}C,^{14}Be)^{48}Ti$ was used to try to measure the mass of particle-bound ^{14}Be. The target was 1.3mg thick, the incident energy was 87.4 MeV and the angle of the detected ejectiles was in the range between 4° to 8°. The solid angle of the detecting system was 4.8 msr. No ^{14}Be event was detected within an energy range of 8 MeV encompassing the expected energy of ^{14}Be particles calculated from the mass predictions. One single event would have corresponded to 20 nb sr^{-1} in the laboratory system.

3 - ^{14}B

The $^{14}C(^{14}C,^{14}B)^{14}N$ single charge exchange reaction was induced on a 50µg cm^{-2} ^{14}C target. The energy spectrum of the ^{14}B emitted nuclei appears in fig. 1.

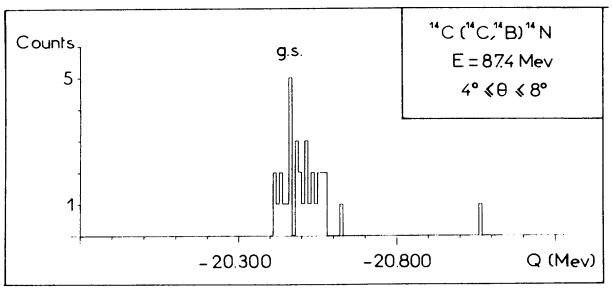

Fig. 1

The ground state peak corresponds to a 23.67 ± 0.03 MeV mass excess for ^{14}B. This is in agreement with previous values [1,5]. The ground state cross section is 7 µb sr^{-1} in the laboratory system.

However there is no evidence for the reported[5] excited level at 0.74 MeV. One event corresponds to an excitation energy of 0.575 MeV. The full width at half maximum of a peak in the energy spectrum is 120 keV. The total statistics collected so far in our study of ^{14}B yields 50 events for the ^{14}B ground state and none for the reported excited state at 0.74 MeV (ref.[1]) and this work). Therefore either this level does not exist or its production is strongly inhibited in the (^{14}C,^{14}B) reaction.

4. ^{18}C

A total of 43 ^{18}C nuclei have been produced in the $^{48}Ca(^{18}O,\ ^{18}C)^{48}Ti$ reaction on a 1.3 mg/cm^2 thick ^{48}Ca target. The energy spectrum of these nu-

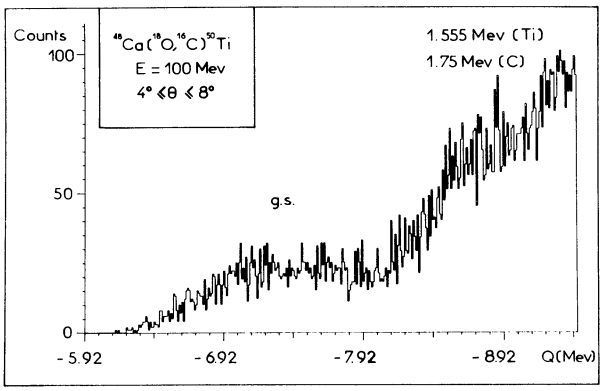

Fig. 2a

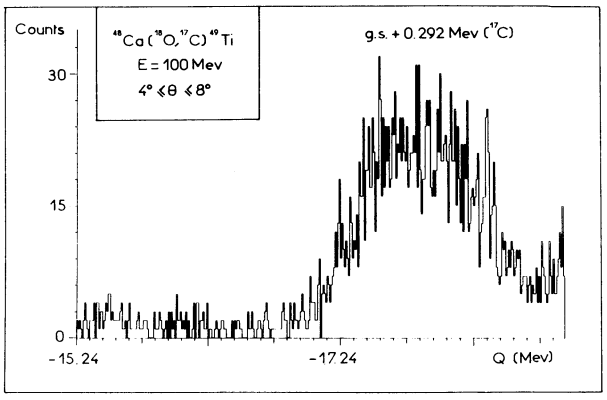

Fig. 2b

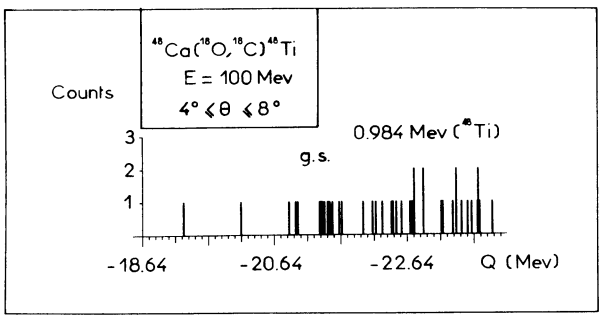

Fig. 2c

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clei is given in fig. 2c, along with the spectra of ^{16}C and ^{17}C (fig. 2a and 2b, respectively) simultaneously collected.

The ^{16}C spectrum provides an energy calibration. The 14 events lying in a 1 MeV interval at high energy in fig. 2c are assigned to the ground state transition. Their centroïd corresponds to a 24.82 ± 0.3 MeV mass excess for ^{18}C and their laboratory cross section is 40 nb sr^{-1}.

The mass measured agrees with the value 24.91 ± 0.15 MeV obtained from the $^{18}O(\pi^-, \pi^+)^{18}C$ reaction[6] and the predictions from the Garvey-Kelson formula calculated[6] with the most recent values of the ^{17}C and ^{19}N masses.

The (^{18}O, ^{18}C) reaction is the first double charge exchange nuclear reaction observed which increases T. The difference between the (^{14}C, ^{14}Be) and (^{18}O, ^{18}C) cross sections should be due to the difference between the reaction Q-values, -33.68 MeV and -21.33 MeV, respectively.

5. ^{18}N

The energy spectrum (fig. 3) of the $^{18}O(^{18}O, ^{18}N)^{18}F$ reaction confirms the occurence of a (0.575 ± 0.025) MeV excited state in ^{18}N reported in ref.[1]). The ^{18}N mass measured is 13.207 ± 0.035 MeV, in agreement with previous values [1,5].

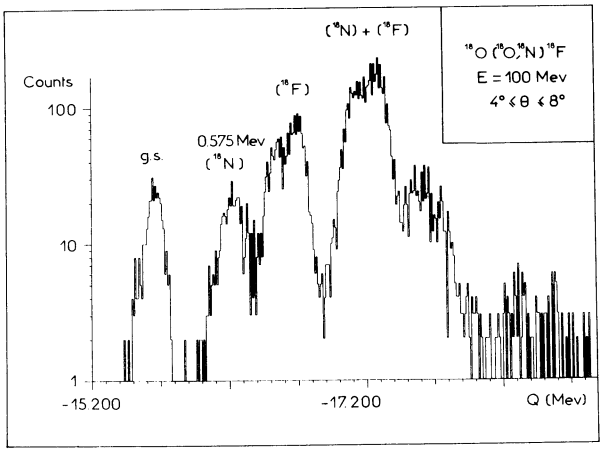

Fig. 3

6. ^{19}N

The complex rearrangement reaction $^{18}O(^{18}O, ^{19}N)^{17}F$ was used to study ^{19}N. The ^{19}N energy spectrum is shown in fig. 4.
Two unknown excited states of ^{19}N appear at 1.12 ± 0.04 and 1.59 ± 0.04 MeV. The ^{19}N mass excess is measured as 15.856 ± 0.05 MeV in agreement with but more accurately than previous reported values [7,8]. The laboratory cross section for the ground state transition is 4.9 μb sr^{-1}.

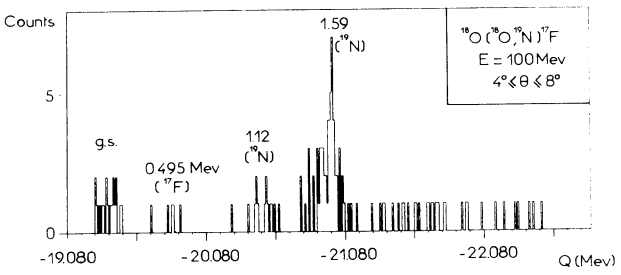

Fig. 4

7. ^{22}O

An attempt was made to observe ^{22}O from the $^{18}O(^{18}O, ^{22}O)^{14}O$ reaction between 4° and 8°. No event was obtained in an energy range of ± 2 MeV around the expected position from the reported ^{22}O mass [9]. On event would have corresponded to a 42 nb sr^{-1} laboratory cross section.

A 450 nb sr^{-1} laboratory cross section was measured elsewhere [9] at 10° for the (^{18}O, ^{14}O) reaction on ^{18}O. If one assumes that the cross section measured [9] at θ_{CM} = 20° would remains constant over the whole C.M. angular range from 10° to 20° in our work, the reported cross section of ref. [9] would corresponds then to 14 ^{22}O events under the conditions of our study. This discrepancy is yet to be understood.

Références

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