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BETA-DELAYED PROTONS* FROM ^{23}Al

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Recent work[1] at this laboratory has established ^{23}Al as the lightest, nucleon-stable member of the $A = 4n + 3$, $T_z = -3/2$ mass series. We wish herein to present a preliminary report of the first observation of the decay of a member of this A, T_z series (in this case, beta-delayed proton emission). Adopting a log ft of 3.3[2] for the superallowed decay of ^{23}Al, and using known log ft values from the mirror decay of ^{23}Ne, one predicts a half-life for ^{23}Al of $\lesssim$ 560 msec. Using standard particle-identifier techniques, a delayed-proton group at 0.88 ± 0.04 MeV (c.m.) following the decay of ^{23}Al was observed with a half-life of 0.48 ± 0.06 sec. The observed protons do not arise from the superallowed transition since the lowest T = 3/2 state in ^{23}Mg, at 7.788 ± 0.025 MeV,[3] is unbound to ^{22}Na + p by only 209 ± 26 keV.

The external proton beam of the Berkeley 88-inch cyclotron was used to induce the ^{24}Mg(p,2n)^{23}Al reaction on a 500 μg/cm^2 target. Protons from the target were detected in a counter telescope consisting of an 8-μm ΔE detector followed by a 50-μm E detector which fed a Goulding-Landis particle identifier. In addition the counter telescope was followed by a 50-μm reject detector. In order to observe low-energy alpha particles and protons, singles spectra were acquired from an additional 14-μm E detector as well as from the 8-μm detector. The counters were mounted downstream from the target behind a slotted, rotating

wheel which controlled the duration of the beam pulse and protected the detectors during the beam-on intervals. Pulsed beams of up to 8 μA were used.

An energy spectrum of identified protons is shown in Fig. 1. The energy calibration was provided by delayed protons from ^{40}Sc produced via the ^{40}Ca(p,n) reaction.[4] In addition to the dominant proton group at 880 keV, protons with energies between 1.1 and 2.1 MeV were observed which possessed a comparable half-life; however further studies are necessary to unequivocally determine their origin. The maximum yield of the 880-keV group is only ∿ 200 nb. The predicted 209-keV (c.m.) proton group from the T = 3/2 state in ^{23}Mg could not have been seen in the single counter energy spectra primarily because of the high background of low-energy ^{16}O recoils arising from the delayed-alpha decay of ^{20}Na (which was also produced in these reactions).

The ^{24}Mg(p,2n)^{23}Al and ^{24}Mg(p,αn)^{20}Na reaction thresholds are 30.78 ± 0.08 MeV and 25.01 ± 0.03 MeV, respectively. These are the only two proton-induced reactions on ^{24}Mg which can lead to the emission of beta-delayed protons and which cannot be readily removed from consideration by threshold measurements. Similarly, there are no reasonable target contaminants which could result in the observed protons. Figure 2 shows excitation-function data which establish ^{23}Al as the only possible source of the observed activity. Figure 2(a) shows an excitation function for the 880-keV identified proton group in which the observed threshold is in agreement with the expected value for the ^{24}Mg(p,2n)^{23}Al reaction. However the ^{24}Mg(p,αn)^{20}Na channel is also open above the observed threshold, and the observed half-life of 0.48 ± 0.06 sec is uncomfortably similar to the ^{20}Na half-life of 0.451 ± 0.002 sec.[5] Figure 2(b) shows the relative cross section ratio of identified protons to the

4.44 MeV α-particle group of ^{20}Na as a function of bombarding energy. This ratio is seen to vary by a factor of ten in both singles counters over the 8 MeV bombarding-energy range shown, which would not be the case if ^{20}Na were the parent of both activities.

This 880-keV (c.m.) proton group, then, can arise only from the decay of ^{23}Al. Modifications to our equipment are in progress to permit the clean observation of quite low-energy particles to search both for the protons resulting from the superallowed beta-decay of ^{23}Al as well as for possible low-energy protons from heavier members of the $A = 4n + 3$, $T_z = -3/2$ series.

FOOTNOTES AND REFERENCES

*Work performed under the auspices of the U. S. Atomic Energy Commission.

†National Research Council of Canada, Postdoctoral Fellow.

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FIGURE CAPTIONS

Fig. 1. An identified proton spectrum arising from the bombardment of ^{24}Mg by 40-MeV protons. A counter telescope consisting of an 8-μm ΔE detector and a 50-μm E detector was employed. The vertical arrows designate the energy region over which protons could be observed.

Fig. 2. (a) An excitation function of identified protons arising from the $^{24}Mg(p,2n)^{23}Al$ reaction.

(b) The yield ratio (^{23}Al identified protons: ^{20}Na α particles) is shown on an arbitrary scale as a function of bombarding energy. The ^{20}Na yield was inferred from the 4.44-MeV α group detected in two independent singles detectors of 8-μm thickness (via the α-particle ΔE loss) and 14 μm thickness (via the total α-particle energy).

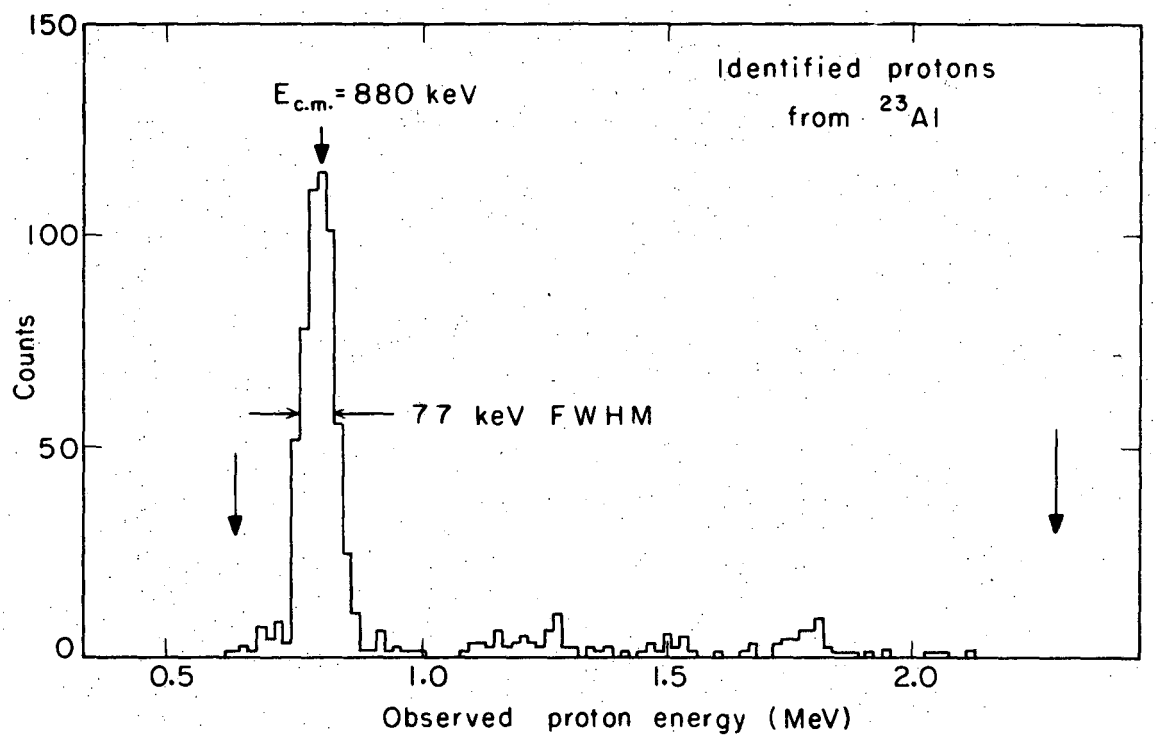

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Fig. 1

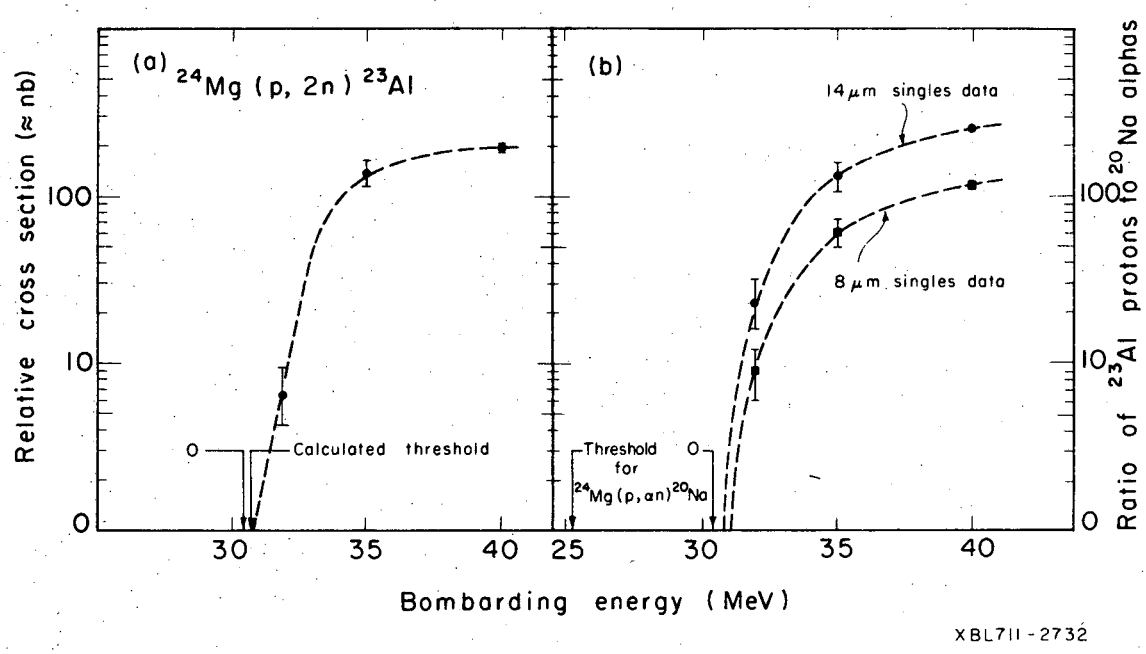
(a) ^{24}Mg (p, 2n) ^{23}Al
Calculated threshold
(b)
14 μm singles data
8 μm singles data
Threshold for ^{24}Mg (p, αn) ^{20}Na
Relative cross section (≈ nb)
Ratio of ^{23}Al protons to ^{20}Na alphas
Bombarding energy (MeV)
XBL711-2732

Fig. 2

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