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# Gamma decay of the first $T = \frac{3}{2}$ level in $^{41}$Sc

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The first $T=\frac{3}{2}$ level in $^{41}$Sc has been excited as a resonance in the $^{40}$Ca$(p,\gamma)^{41}$Sc reaction, at incident energy $E_p = 4974 \pm 5$ keV. Transitions to the levels at 2.668, 3.415, 3.777, and 4.248 MeV have been observed, and their radiative widths determined. Multipole mixing ratios have been obtained from angular distribution measurements. The comparison between radiative strengths and $ft$ values for the $\beta^+$ decay of the $^{41}$Ti ground state suggests that an important part of the $[(1f_{7/2}{}^2)_{j=1,\,t=0}1d_{3/2}{}^{-1}]_{J=5/2,\,T=1/2}$ configuration could be in the 4.248-MeV level. The $\gamma$ decay of the first $T=\frac{3}{2}$ level is also compared with that of its analog in $^{41}$Ca, giving strong indication that the $T=\frac{1}{2}$ levels in $^{41}$Sc at 2.668, 3.415, 3.777, and 4.248 MeV are, respectively, the analog of those at 2.605, 3.400, 3.740, and 4.094 MeV in $^{41}$Ca.

[NUCLEAR REACTIONS $^{40}$Ca$(p,\gamma)$, $E$=4971–4979 keV; measured $\sigma(E_p;\, E_\gamma;\, \theta_\gamma)$. First $T=\frac{3}{2}$ level in $^{41}$Sc, deduced energy, resonance strength, radiative widths, mixing ratios. Ge(Li) detectors, enriched target.]

## I. INTRODUCTION

In a first approximation, Coulomb and other charge-dependent forces can be considered negligible as compared with nuclear forces. From this assumption, isospin is a good quantum number and the same energy spectrum is observed in two mirror nuclei with pairs of analog levels. Since only the isovector part of the electromagnetic interaction contributes in a $\gamma$ transition between levels of different isospin, corresponding $\Delta T = 1$ transitions in mirror nuclei are predicted to have equal strengths and mixing ratios.[1]

This experiment was conducted in order to test this rule in the mirror nuclei $^{41}$Ca and $^{41}$Sc, and then to identify pairs of analog $T=\frac{1}{2}$ levels. Results about the $\gamma$ decay of the first $T=\frac{3}{2}$ level in $^{41}$Ca have been reported in Ref. 2. In the present experiment, the reaction $^{40}$Ca$(p,\gamma)^{41}$Sc is used to study the $\gamma$ decay of its analog in $^{41}$Sc.

In this isospin-forbidden reaction, the $T=\frac{3}{2}$ level is excited in a nonselective way, through isospin impurities in its wave function and/or in that of the target nucleus. Results about the $\beta^+$ decay of the $^{41}$Ti ground state[3,4] are useful to identify the $T=\frac{3}{2}$ resonance. The resonance energy can be deduced from that of protons emitted after the superallowed Fermi transition between members of the same isospin quadruplet. Furthermore, one can roughly predict the $\gamma$ decay of the $T=\frac{3}{2}$ level by considering the strengths of the $\beta$ transitions from the $^{41}$Ti ground state to $T=\frac{1}{2}$ levels in $^{41}$Sc. The Gamow-Teller matrix element $\Lambda$(GT) can be extracted from the $ft$ value of a $\Delta T = 1$ $\beta$ transition, using the relation[4]

$$ft\,(s) = \frac{3940}{\Lambda(\mathrm{GT})}\,. \tag{1}$$

For the corresponding $\gamma$ transition to the same final level, the spin part $\langle f|s\tau|i\rangle^2$ of the $M1$ isovector matrix element can be identified with $\frac{1}{2}\Lambda$(GT).[5] Then the following relation between the $M1$ strength and the $ft$ value for the analog $\beta$ transition can be deduced from Ref. 4 and Eq. (1):

$$B(M1) = B(M1;\sigma)\left(1 + 0.118\frac{\langle f|j\tau|i\rangle}{\langle f|s\tau|i\rangle}\right)^2, \tag{2}$$

where $\langle f|j\tau|i\rangle$ is the total angular momentum part of the $M1$ operator and

$$B(M1;\sigma)(\mu_0{}^2) = \frac{5549}{ft(s)}\,. \tag{3}$$

The second term in parentheses is often small,[5] and $B(M1)$ values are then expected to be of the same magnitude order as the $B(M1;\sigma)$ values, deduced from the corresponding $\beta$ strength. This relation between analog $\beta$ and $\gamma$ decay can be used as an additional argument to identify the $T=\frac{3}{2}$ resonance.

## II. EXPERIMENTAL METHOD AND RESULTS

### A. Experimental arrangement

A proton beam was obtained from the 5.5-MV Van de Graaff accelerator of the Centre de Recherches Nucléaires in Strasbourg-Cronenbourg. Metallic calcium (99.9% enriched in $^{40}Ca$) was evaporated onto tungsten backings. The targets were kept in vacuum, and they were water-cooled during the experiment, allowing a 3-$\mu$A beam intensity.

A 120-cm$^3$ Ge(Li) detector was placed at 3 cm from the target, at 55° with respect to the beam direction. A 4-keV resolution was achieved at the counting rate observed in the experiment. The energy calibration was done at each run, using the precisely known energies[6] of $\gamma$ rays from $(p, p'\gamma)$ and $(p, \alpha\gamma)$ reactions on contaminants, observed in the Ge(Li) spectra.

The calibration of the analyzing magnet was done in a preliminary study of the $^{40}Ca(p,\gamma_0)^{41}Sc$ reaction at proton energies between 4.80 and 4.85 MeV, using a 70-$\mu$g/cm$^2$-thick target. The reaction $Q$ value, measured in Ref. 7, is 1085.7 ± 1.4 keV; the energies of two strong resonances, observed in this experiment, were deduced from the measured energies of the $\gamma$ transition to the ground state, corrected for Doppler shift, and then used for the calibration of the magnet. The resonance energies thus determined are $E_p = 4806 \pm 4$ and $4843 \pm 4$ keV. These two resonances can be identified with those found in the same reaction by Youngblood, Wildenthal, and Class[8] at 4812 ± 8 and 4850 ± 8 keV.

### B. Excitation function

The decay energy of the $T = \frac{3}{2}$ level, measured in the study of the $\beta^+$ decay of $^{41}Ti$,[3] corresponds to a resonance energy $E_p = 4973 \pm 6$ keV in the $^{40}Ca + p$ channel. Therefore the incident energy was varied by 0.75-keV steps around the expected resonance energy. A 70-$\mu$g/cm$^2$-thick $^{40}Ca$ target was used, inducing a 3.5-keV energy loss for the incident beam. At each energy, Ge(Li) spectra were stored in 5000-$\mu$C runs in order to search for resonant $\gamma$ rays. A resonance at 4974 keV has been observed for a 1.690-MeV $\gamma$ ray, with an experimental width accounted for by the target thickness. The excitation function for this transition is shown in Fig. 1.

This resonance has been further investigated using a 8-keV-thick $^{40}Ca$ target in order to measure the resonance strength and look for weaker transitions. Eight high-statistics Ge(Li) spectra were stored at incident energies below and above the resonance. One spectrum is shown in Fig. 2.

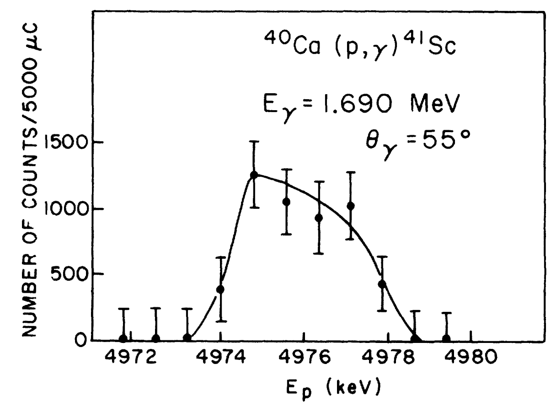


FIG. 1. Excitation function at 55° for a 1.690-MeV $\gamma$ ray, observed in the $^{40}Ca(p,\gamma)^{41}Sc$ reaction with a 3.5-keV-thick target. The line is only to guide the eyes.

The total charge accumulated was 126 000 $\mu$C.

In addition to the 1.690-MeV transition, three weaker $\gamma$ rays were also observed, resonating at the same energy $E_p = 4974 \pm 5$ keV. This incident energy corresponds to an excitation energy $E_x = 5938 \pm 5$ keV in $^{41}Sc$, deduced from the reaction $Q$ value determined in Ref. 7. The energies of observed resonant $\gamma$ rays, corrected for full Doppler shift, are listed in Table I. The differences between $E_x$ and each energy of the four transitions correspond to known[6] excitation energies in $^{41}Sc$. These transitions are then identified with those from the resonance level to the levels at 2.668, 3.415, 3.777, and 4.248 MeV in $^{41}Sc$. Secondary $\gamma$ transitions from these levels are unobserved, because they preferentially decay by proton emission. We do not observe resonance at this energy for the $\gamma$ rays at 3.737 and 3.904 MeV emitted in the $^{40}Ca(p,p'\gamma)^{40}Ca$ reaction.

The excitation function of the four $\gamma$ rays, obtained by measuring the area of the full energy peaks, are shown in Fig. 3. Errors below the resonance are estimated as twice the statistical errors on the background, at the position of the $\gamma$-ray peak. A contaminant $\gamma$ ray, presumably from the $^{39}K(p,p'\gamma)^{39}K$ reaction, is not resolved from the 5.938 → 3.415-MeV transition and the total yield for both components of the 2.523-MeV $\gamma$ ray is shown in Fig. 3.

Relative efficiency was measured *in situ* after the experiment, using a $^{56}Co$ source at the position of the beam on the target backing. The absolute efficiency of the detector at 1.17 and 1.33 MeV was deduced from the intensity of the additional peak of $\gamma$ rays emitted by a $^{60}Co$ source, placed at the same position. Systematic errors on absolute efficiencies thus determined are evaluated as below 5%.

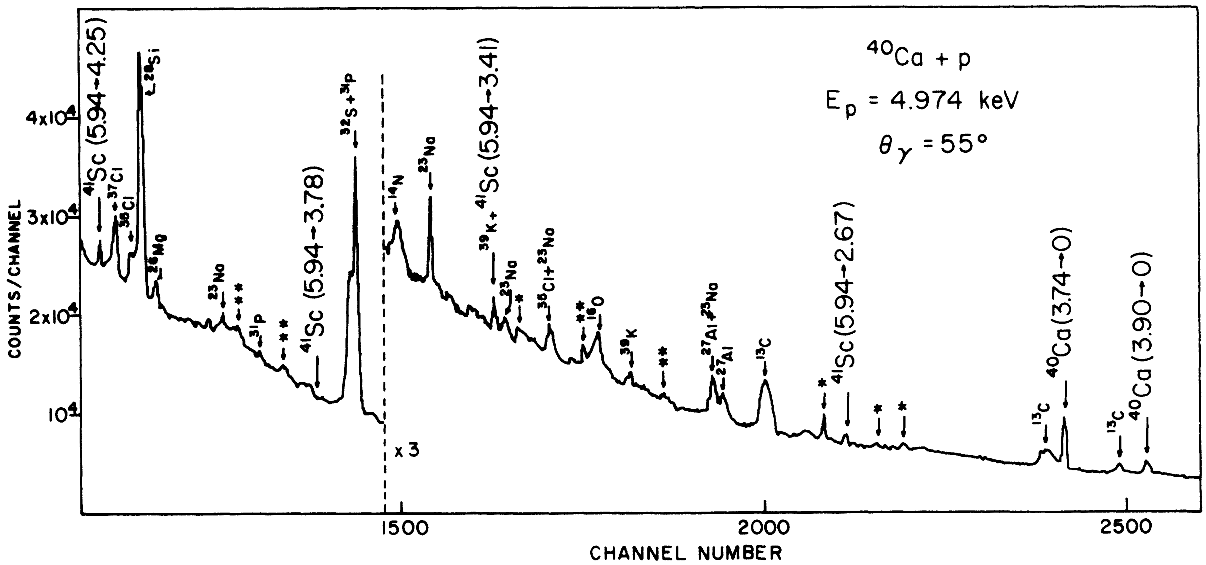


FIG. 2. Spectrum of $\gamma$ rays emitted at 55° in the $^{40}$Ca+$p$ reaction, on the resonance at $E_p$ = 4974 keV. The target thickness is 160 $\mu$g/cm$^2$. $\gamma$ rays from $(p,p'\gamma)$ and $(p,\alpha\gamma)$ reactions on comtaminants in the target are labeled by the name of the final nuclei. Single- and double-escape peaks are labeled, respectively, by single and double asterisks.

### C. Determination of the resonance strength

The step in the thick target yield for each four transitions was obtained by averaging the number of counts of the four incident energies investigated above the step; for the 2.523-MeV transition mixed with a contaminant, the average number of counts in the $\gamma$-ray peak, observed at the three energies below the resonance, has been subtracted.

Branching ratios are reported in Table I. The resonance strength $(2J+1)\,\Gamma_p\,\Gamma_\gamma/\Gamma$ for the four observed transitions, calculated by assuming an infinitely thick target and using the stopping power values in calcium given in Ref. 9, is 0.499 ± 0.090 eV.

### D. Angular distribution measurements

The angular distribution of $\gamma$ rays on resonance has been obtained by measurements at 0°, 45°, and 90° in two runs of 40 000 $\mu$C. The 120-cm$^3$ Ge(Li) detector was placed successively at 0° and 45° at

TABLE I. Properties of $\gamma$ rays from the resonance $E_p$ = 4974 keV in the $^{40}$Ca$(p,\gamma)$ reaction.

| $E_\gamma$ (keV) | Final level $E_f$ (MeV) | $J^\pi$ | Branching ratio (%) | $A_2/A_0$ | Initial spin (possible) | $\delta$ [a] |
|---|---|---|---|---|---|---|
| 1690.4 ± 0.8 | 4.248 | $\frac{5}{2}^+$ | 60 ± 3 | −0.04 ± 0.02 | $\frac{1}{2}$ | $-\infty<\delta<\infty$ |
| | | | | | $\frac{3}{2}$ | 0.04 ± 0.08 or 3.7 ± 1.0 |
| | | | | | $\frac{5}{2}$ | 0.40 ± 0.06 |
| | | | | | $\frac{7}{2}$ | −0.15 ± 0.04 |
| 2161.0 ± 1.5 | 3.777 | $\frac{5}{2}^+$ | 5 ± 3 | | | |
| 2523.0 ± 2.4 | 3.415 | $\frac{1}{2}^+$ | 18 ± 3 | | | |
| 3270.4 ± 1.5 | 2.668 | $\frac{5}{2}^+$ | 17 ± 2 | 0.27 ± 0.21 | $\frac{1}{2}$ | $-\infty<\delta<\infty$ |
| | | | | | $\frac{3}{2}$ | 0.41 ± 0.16 or 1.5 ± 0.4 |
| | | | | | $\frac{5}{2}$ | 0.13 ± 0.23 |
| | | | | | $\frac{7}{2}$ | −0.31 ± 0.14 |

[a] The sign of $\delta$ is defined according to the phase convention of Rose and Brink (Ref. 11).

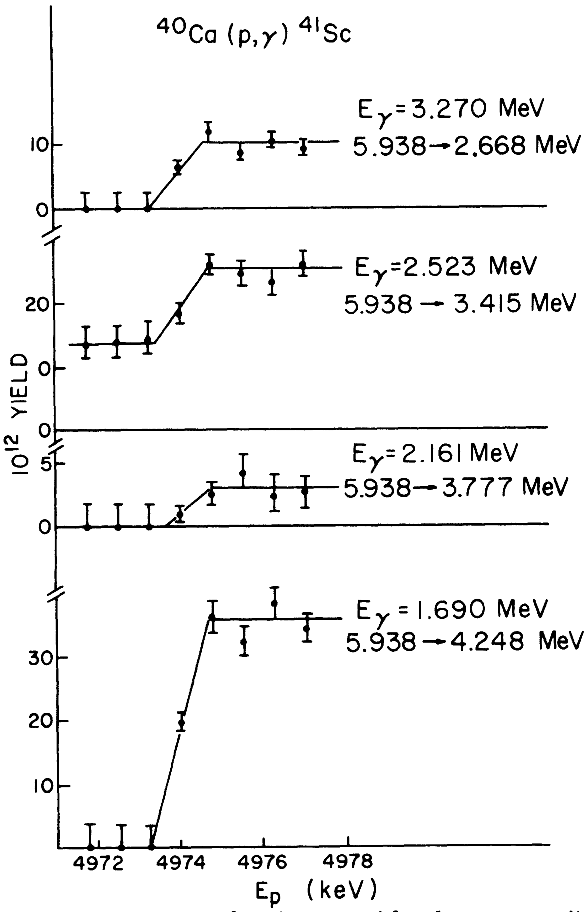


FIG. 3. Excitation functions at 55° for the $\gamma$ rays emitted by the resonance at $E_p = 4974$ keV in the $^{40}$Ca$(p,\gamma)^{41}$Sc reaction, observed with a 8-keV-thick target.

5 cm of the target; a 84-cm$^3$ Ge(Li) detector was located at $-90°$ during the two runs. Efficiencies of the detectors, relative to the $\gamma$-ray energies and the detector position, were determined *in situ* after the experiment, using a $^{56}$Co source put on the target backing at the beam position.

Results for the transitions to the levels at 4.248 MeV $[J^\pi = \frac{5}{2}^+$ (Ref. 8)$]$ and 2.668 MeV $[J^\pi = \frac{3}{2}^+$ (Ref. 4)$]$ are given in Table I. Coefficients of Legendre polynomials are corrected for geometrical effects.[10] The values of the multipole mixing ratio $\delta$, giving the best fit of the experimental angular distribution to the theoretical one, are reported in Table I for each initial spin not rejected by the 0.1% limit.

## III. DISCUSSION

### A. Identification of the studied resonance with the $T = \frac{3}{2}$ level

Limitations on spin and parity for the 5.938-MeV level can be deduced from the transitions strengths measured in the present experiment: $J = \frac{1}{2}$ is excluded because the strength of the transition to the $\frac{5}{2}^+$ level at 4.248 MeV would be stronger than the upper limit recommended in Ref. 12. One can also exclude $J^\pi = (\frac{5}{2}^-, \frac{7}{2}^\pm)$ because of the strength of the transition to the $\frac{1}{2}^+$ level at 3.415 MeV. One then assigns $J^\pi = (\frac{3}{2}^\pm, \frac{5}{2}^+)$ to the 5.938-MeV level.

The energy of the resonance measured in this experiment is consistent with that expected for the $T = \frac{3}{2}$ level, deduced from Ref. 3, and that of a $\frac{3}{2}^+$ resonance, observed with a 55-eV width at $4978 \pm 5$ keV in the $^{40}$Ca$(p,p)^{40}$Ca reaction.[13] The levels fed in its $\gamma$ decay are also fed in the $\beta^+$ decay of the $^{41}$Ti ground state,[4] as it is expected for the $T = \frac{3}{2}$ level. All these results strongly indicate that the 5.938-MeV level is indeed the first $T = \frac{3}{2}$ level in $^{41}$Sc.

The Coulomb energy difference between the first $T = \frac{3}{2}$ levels in $^{41}$Sc and $^{41}$Ca, combining the ground state binding energies of Ref. 14 with the energy in $^{41}$Ca determined in Ref. 2, is then $7400 \pm 9$ keV.

Radiative widths can be calculated if one assumes that $\Gamma_p/\Gamma$ is equal to 1. This assumption is justified because the branching ratio to the $0^+$ level at 3.35 MeV in $^{40}$Ca is lower than 3% of the ground state decay[4] and resonances in the $^{40}$Ca$(p,p'\gamma)^{40}$Ca reaction are not observed in this experiment. Measured radiative widths are reported in Table II.

The observation of weaker transitions from the $T = \frac{3}{2}$ level could have been hindered by the high background in the Ge(Li) spectra. In this case, the upper limit to their radiative widths would be about 3 meV at a 4-MeV $\gamma$-ray energy and 7 meV at 1.5 MeV. This limit could be higher if there is a contaminant peak near the energy expected for the transition: It is the case for a possible $\gamma$ transition to the 2.097-MeV level, analog of an observed $\beta$-transition.[4]

### B. Comparison between strengths of corresponding $\beta$ and $\gamma$ transitions

The $B(M1)$ values found in this experiment are reported in Table II. For the transitions to the 2.668- and 4.248-MeV levels, they are estimated with the lower values of $\delta$ deduced from the angular distribution measurement (the higher ones are excluded because they would correspond to unlikely high $E2$, $\Delta T = 1$ strengths).[12] For the other transitions, they are calculated assuming $\delta$ equal to 0.

The corresponding $B(M1;\sigma)$ values defined in Eq. (3), and deduced from the results of Ref. 4, are also reported in Table II for comparison.

Relation (2) enables one to experimentally evaluate the ratio $R = \langle f|j\tau|i\rangle / \langle f|s\tau|i\rangle$, which is closely related to the structure of initial and final

TABLE II. Comparison between the $\beta^+$ decay of $^{41}$Ti and the $\gamma$ decay of the $(\frac{3}{2}^+, T=\frac{3}{2})$ level at 5.938 MeV in $^{41}$Sc.

| $\beta$ decay of $^{41}$Ti [a] | | | | $\gamma$ decay of the $T=\frac{3}{2}$ level in $^{41}$Sc [b] | | |
|---|---|---|---|---|---|---|
| Final level $E_x$ (keV) | $J^\pi$ | $ft$ ($10^3 s$) | $B(M1;\sigma)$ ($\mu_0^2$) | Final level $E_x$ (keV) | $\Gamma_\gamma$ [c] (meV) | $B(M1)$ ($\mu_0^2$) |
| 2097 ± 6 | $\frac{3}{2}^+$ | 61.5 ± 4.4 | 0.090 | | <16 | <0.024 |
| 2667 ± 3 | $\frac{5}{2}^+$ | 82.5 ± 3.9 | 0.067 | 2668 ± 5 | 21 ± 5 | 0.043 |
| 3415 ± 2 | $\frac{1}{2}^+$ | 45.6 ± 2.2 | 0.121 | 3415 ± 5 | 23 ± 6 | 0.124 |
| 3556 ± 20 | | 74.6 ± 3.1 | 0.074 | | <15 | <0.096 |
| 3783 ± 2 | $\frac{5}{2}^+$ | 119 ± 12 | 0.046 | 3777 ± 5 | 6 ± 4 | 0.051 |
| 3970 ± 2 | $\frac{1}{2}^+$ | 176 ± 19 | 0.031 | | <7 | <0.079 |
| 4248 ± 2 | $\frac{5}{2}^+$ | 12.0 ± 0.9 | 0.462 | 4248 ± 5 | 75 ± 14 | 1.332 |

[a] See Ref. 4. Only the final levels observed below 4.3 MeV are displayed.

[b] Present work. Energies of final levels are determined by the difference between the energy of the resonance level and measured $\gamma$-ray energies.

states. For an $M1$, $\Delta T=1$ transition inside a $(n,l,j)$ shell, the theoretical ratio is equal to $(-)^{j+l-1/2}(2l+1)$ and it is equal to 0 in a $(n,l,j) \to (n,l,j\pm1)$ transition.[1]

In a first approximation, one can expect that the structure of the first $T=\frac{3}{2}$ level is mainly $[(1f_{7/2}{}^2)_{j=0,t=1}1d_{3/2}{}^{-1}]_{J=3/2,T=3/2}$. The only configurations which can be populated in a pure $M1$ $\gamma$ decay are the antianalog configuration $[(1f_{7/2}{}^2)_{j=0,t=1}1d_{3/2}{}^{-1}]_{J=3/2,T=1/2}$ and the configurations $[(1f_{7/2}{}^2)_{j=1,t=0}1d_{3/2}{}^{-1}]_{J=1/2,3/2,5/2,T=1/2}$. The theoretical value of $R$ is then equal to $-5$ for the analog-to-antianalog transition; it is equal to $+7$ for the transitions to the other configurations.

Experimentally, $R$ is found to be equal to 6 for the transition to the 4.248-MeV level. This indicates that the $[(1f_{7/2}{}^2)_{j=1,t=0}1d_{3/2}{}^{-1}]_{J=5/2,T=1/2}$ configuration could play an important part in the wave function of the 4.248-MeV level. The transition strength is 0.73 Weisskopf units (W.u.). The theoretical value for the transition to the $\frac{5}{2}$ member of the configuration, calculated using standard methods of tensor algebra[15] with bare nucleon $g$ factors, is 3.4 W.u. One could suggest that other components of this configuration could be at higher energy: In this case, the corresponding low energy $\gamma$ rays could not be observed in the present experiment.

The $\gamma$ transition, analog of the $\beta^+$ transition to the $\frac{3}{2}^+$ level at 2.097 MeV,[4] has not been observed and from the upper limit to the radiative width, $R$ is found lower than $-4$. This value is consistent with that theoretically expected if one assumes that the 2.097-MeV level is the antianalog state.

In the limit of experimental errors, there is a good agreement between the corresponding $B(M1)$ and $B(M1;\sigma)$ values for the other transitions. This is probably due to the fact that configuration mixings in the wave functions of final states are more important than for the 2.097- and 4.248-MeV levels.

### C. Identification of analog $T=\frac{1}{2}$ levels in $^{41}$Ca and $^{41}$Sc

Relative intensities of transitions from the first $T=\frac{3}{2}$ level in $^{41}$Ca, deduced from branching ratios measured in Ref. 2, are compared in Table III with those observed in this experiment for the $\gamma$ decay of its analog in $^{41}$Sc. The good agreement between experimentally observed relative intensities in $^{41}$Ca and $^{41}$Sc is consistent with the expectations for corresponding $\Delta T=1$ transitions.

TABLE III. Comparison between the $\gamma$ decay of the first $T=\frac{3}{2}$ levels in $^{41}$Ca and $^{41}$Sc.

| $^{41}$Sc ($E_i$ = 5.938 MeV) [a] | | | $^{41}$Ca ($E_i$ = 5.817 MeV) [b] | | |
|---|---|---|---|---|---|
| $E_f$ (MeV) | $J^\pi$ | Relative intensity [c] | $E_f$ (MeV) | $J^\pi$ | Relative intensity [c] |
| 2.097 | $\frac{3}{2}^+$ | <1 | 2.010 | $\frac{3}{2}^+$ | <0.3 |
| 2.668 | $\frac{5}{2}^+$ | 4.0 ± 0.5 | 2.605 | $(\frac{5}{2}^+)$ | 3.5 ± 0.6 |
| 3.415 | $\frac{1}{2}^+$ | 9.3 ± 2.0 | 3.400 | $\frac{1}{2}^+$ | 10.9 ± 1.6 |
| 3.777 | $\frac{5}{2}^+$ | 3.8 ± 2.5 | 3.740 | $\frac{5}{2}^+$ | 9 ± 5 |
| 4.248 | $\frac{5}{2}^+$ | 100 | 4.094 | $(\frac{5}{2})^+$ | 100 |
| ... | | ... | 4.728 | $(\frac{1}{2},\frac{3}{2})^+$ | 82 ± 16 |

[a] Present work.

[b] See Ref. 2.

[c] Relative intensities are branching ratios divided by $E_\gamma{}^3$ and arbitrarily normalized.

This result can be used to identify pairs of analog $T=\frac{1}{2}$ levels in $^{41}$Ca and $^{41}$Sc and to propose a $J^\pi$ assignment for a level if it is known for the corresponding level in the mirror nucleus.

The strong decay to the 4.248-MeV level in $^{41}$Sc corresponds to that observed in $^{41}$Ca to the 4.094-MeV level. The 4.248-MeV level in $^{41}$Sc has $J^\pi=\frac{5}{2}^+$.[8] The 4.094-MeV level in $^{41}$Ca is excited by $l=2$ pickup in the $^{42}$Ca$(p,d)^{41}$Ca reaction[16] and its $\gamma$ decay strongly suggests $J^\pi=\frac{5}{2}^+$.[17] The present work also supports this spin assignment.

The mirror transitions to the levels at 3.415 MeV in $^{41}$Sc ($J^\pi=\frac{1}{2}^+$) and 3.400 MeV in $^{41}$Ca ($J^\pi=\frac{1}{2}^+$) confirms the analogy of these levels.

The weak 5.938 → 3.777-MeV transition in $^{41}$Sc could correspond to the 5.817 → 3.740-MeV transition in $^{41}$Ca. From the results of Refs. 16 and 18, one can assign $J^\pi=\frac{5}{2}^+$ to the 3.740-MeV level. The 3.777-MeV level can probably be identified with the $\frac{5}{2}^+$ level observed at 3.783 MeV in the $^{40}$Ca$(p,\gamma_0)^{41}$Ca reaction.[8]

The analogy between the 2.668-MeV level in $^{41}$Sc and the 2.605-MeV level in $^{41}$Ca seems to be clearly established in this work. The 2.668-MeV level has $J^\pi=\frac{5}{2}^+$ [according to empirical rules for strengths of $\beta$ transitions,[19] the $ft$ value for the $\beta^+$ transition to the 2.668-MeV level[4] excludes the other possibilities $\frac{5}{2}^-$ and $\frac{9}{2}^+$, also consistent with angular distribution results in the $^{40}$Ca$(p,\gamma)$-$^{41}$Sc reaction[8]]. We then suggest that the 2.605-MeV level has also $J^\pi=\frac{5}{2}^+$, in agreement with a previous proposition.[20] The disagreement with a $l=3$ assignment for the 2.605-MeV level in the $^{42}$Ca$(^3$He$,\alpha)^{41}$Ca reaction[21] could be due to the similarity of $l=2$ and $l=3$ angular distributions patterns.

The transition in $^{41}$Sc analog of the strong 5.817 → 4.728-MeV transition in the $^{41}$Ca has not been observed because of high background and contaminant peaks. Finally, one does not observe the analog-to-antianalog transition neither in $^{41}$Ca (5.817 → 2.010 MeV) nor in $^{41}$Sc (5.938 → 2.097 MeV). Such a retardation is expected for a $1d_{3/2} \to 1d_{3/2}$ analog-to-antianalog transition.[22]

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