THE DECAY OF ^{35}K

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ABSTRACT

A new nuclide, ^{35}K , has been identified and its decay has been studied. Its half-life was determined to be 190 ± 30 ms. Spectra of β -delayed protons and γ -rays from the decay of this nuclide have been obtained. A decay scheme is proposed, taking into account 18 of the 19 observed γ -rays and 5 of the 10 observed proton groups. Log ft values have been deduced for 11 β -transitions populating excited states in ^{35}Ar . These values and the level structure in ^{35}Ar are compared with shell model calculations.

[RADIOACTIVITY ^{35}K [from $^{45}\text{Sc}(p,3p8n)$, chem. mass. separation];
measured E_γ , I_γ , E_p , I_p , $T_{1/2}$, deduced ft values. ^{35}Ar deduced levels.
Ge(Li), surface barrier Si detectors.]

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1. INTRODUCTION

There are fifteen $T_z = -3/2$ nuclides whose decays are currently known. Fourteen of them have even Z and comprise the well-known series of $A = 4n + 1$ β -delayed proton precursors¹⁾, their decays being characterized by strong proton-emitting branches. The fifteenth, ^{23}Al , has odd Z and is also a delayed proton precursor²⁾, although that decay channel is almost certainly weak. In all cases, only the proton decay mode has been carefully studied, because it offers such a characteristic signature. No detailed γ -spectroscopic investigation of the decay of any nuclide with $T_z = -3/2$ has been made so far.

The weakness of delayed-proton branches from odd Z $T_z = -3/2$ nuclides arises from the high proton separation energy of their β -decay daughters, nuclides with an even number of protons. As a result, most states populated in β -decay - including the $T = 3/2$ analogue state - can themselves decay only by γ -ray emission. This is in striking contrast to the $A = 4n + 1$ series, whose proton spectra are dominated by peaks from the decay of the analogue state. Because $T_z = -3/2$ nuclides have low production cross sections and cannot be produced selectively in any nuclear reaction, the preponderance of γ emission for those nuclides with odd Z has hindered their observation since they could not be identified amongst competing activities. In the present experiment that difficulty was obviated through the use of an on-line isotope separator.

We wish to report here the identification of a second $T_z = -3/2$ nuclide with odd Z : ^{35}K . In addition to β -delayed protons, we have observed a number of γ -transitions following its β -decay. We propose a decay scheme encompassing all but one of the detected γ -rays as well as some of the proton transitions, which are all relatively weak.

The ^{35}Ar level scheme deduced from our results includes several new spins, improved energy determination of a number of levels including the $T = 3/2$ analogue state, as well as $\log ft$ values for β -transitions from ^{35}K . The scheme is compared with levels in the mirror nucleus, ^{35}Cl , and with shell model calculations. The improved energy of the $T = 3/2$ state leads to significant tests of the isobaric multiplet mass equation and Coulomb energy systematics.

2. EXPERIMENTAL TECHNIQUE

Neutron-deficient potassium isotopes were produced at the ISOLDE facility at CERN through spallation reactions induced by a $1.7\ \mu\text{A}$ beam of 600 MeV protons from the synchrocyclotron. The target of $13.6\ \text{g}/\text{cm}^2$ of ScC_2 was held at a temperature of $\sim 2000^\circ\text{C}$. The reaction products diffused out of the hot target and reached a tungsten surface ionization source where potassium isotopes were selectively ionized. The beam extracted from the ion source was separated into its constituent atomic masses by the ISOLDE analyzing magnet. The beam corresponding to mass 35 was transported to a low background counting area where it was collected on a thin mylar foil.

Gamma rays from the collected activity were detected by a $109\ \text{cm}^3$ $\text{Ge}(\text{Li})$ detector situated 2 cm behind the mylar foil. The detector had a resolution of 2.1 keV FWHM at 1.33 MeV. Energy and efficiency calibrations were made with a ^{56}Co source. The ^{56}Co γ -ray energies were taken from a compilation by Greenwood et al³⁾, with absolute intensities from a paper by Gehrke et al⁴⁾.

In order to determine the half-life of observed γ -ray peaks, the collection could be interrupted periodically by deflecting the ^{35}K beam

electrostatically. Seven γ -ray spectra were then recorded sequentially. In addition, a lifetime for the total positron activity was determined by multi-scaling events corresponding to minimum ionizing positrons traversing a 700 μm thick Si surface barrier detector.

A detector telescope was used to observe β -delayed charged-particle branches in the decay of ^{35}K . In this experiment the mylar collector was replaced by a 20 $\mu\text{g}/\text{cm}^2$ thick carbon foil. The telescope, mounted 6 mm behind the foil, consisted of two silicon surface barrier detectors (ΔE : 20 μm , 50 mm^2 and E: 700 μm , 150 mm^2) and subtended a solid angle of 4.7% of 4π sr. The alpha groups from a combined source of ^{239}Pu , ^{241}Am and ^{244}Cm were used to calibrate the energy response of the telescope. The linearity of the system was checked with a precision pulser. The energy resolution was measured to be 50 keV (full width at half maximum).

3. EXPERIMENTAL RESULTS

A γ -ray spectrum accumulated for 55 min. from a saturated source of ^{35}K is shown in Fig. 1. After accounting for single and double escape peaks as well as peaks due to coincident summing, 20 γ -transitions not found in the room background were observed. One of these, at an energy of 2168 keV, was identified as coming from the decay of $^{38,5}\text{K}$, which was apparently present as a weak cross-contamination in the separator. The remaining 19 transitions were assigned to the decay of ^{35}K . They are indicated in Fig. 1 with their energies and relative intensities presented in Table 1.

In this experiment, γ -rays with energies up to 5 MeV were recorded. It was noted that one of the high energy peaks, at 4550 keV (Nr 19 in Fig. 1), did not produce a single or double escape peak, contrary to the findings for other peaks with similar intensities in the same energy range. The 4550 keV peak was therefore interpreted as being the double escape peak of a 5572 keV γ -transition, for which there is other corroboratory evidence.⁶⁾

No β -delayed γ -rays were seen from the decay of ^{35}Ar , the daughter product of ^{35}K . ^{35}Ar is known to decay with 98.3% of the β -intensity⁵⁾ populating the ground state of ^{35}Cl .

Only the three strongest γ -rays assigned to the decay of ^{35}K , i.e. the 2983, 2590 and 1751 keV γ -rays, and the annihilation peak were sufficiently intense to warrant a half-life measurement. A multispectrum analysis of the decays of these peaks, yielded statistically consistent results, which also agreed with the value obtained from multiscaling the total positron activity. The weighted average of these measurements yields a half-life for ^{35}K of 190 ± 30 ms.

The spectrum of charged particles from ^{35}K is shown in Fig. 2. Ten distinct proton groups were found in this spectrum. The emission of both β -delayed protons and β -delayed alphas is energetically possible in the decay of ^{35}K , but only protons were detected. The energies and the relative intensities of the proton groups are given in Table 2. The total proton intensity was also measured to be $(7.3 \pm 3.0) \times 10^{-3}$ relative to the number of 2983 keV γ -rays.

4. THE ^{35}K (β^+) ^{35}Ar DECAY SCHEME

The proposed decay scheme for ^{35}K is shown in Fig. 3. It includes 18 out of the 19 γ -transitions assigned to the decay of this nuclide. Only the weak peak at 2698 keV is unassigned. The arguments supporting the scheme are based on energy sums of the γ -rays found in this work, existing data⁵⁾ on levels in ^{35}Ar and comparisons with the mirror nucleus ^{35}Cl . The energies of the excited states given in Fig. 3 and Table 3 were obtained from averages of the sums and differences of the energies of relevant γ -rays corrected for nuclear recoil.

The relative intensities of β -transitions populating the levels in ^{35}Ar were established by comparing the total γ -ray intensity depopulating each level to that seen feeding it. In complex decay schemes of heavy nuclides this method is known⁷⁾ to be suspect since there is significant γ -ray intensity that is unobserved because it lies in a multitude of very weak γ -ray peaks. In a nucleus as light as ^{35}K the problem is less acute. We have generated a "pandemonium test" in the same spirit as in ref. 7 and find that less than one percent of the γ -ray intensity from ^{35}K decay should be missed for that reason.

To transform the relative β -transition intensities into absolute values, the intensity of the branch populating the ^{35}Ar ground state must be determined. Since in our experiment the decay positrons were not annihilated in a localized environment, we must rely on estimating that intensity. To do so we note that in the absence of charge-dependent forces, allowed mirror β -transitions are expected to have identical transition rates. However, a small asymmetry, $\delta = ft^+/ft^- - 1$, mainly the result of the symmetry-breaking Coulomb

force, is known to occur. (The + and - superscripts denote the β^+ and β^- emitting nuclides respectively.) The magnitude of this asymmetry has been measured to be between +6 and +19% for a number of p-shell multiplets⁸⁾.

The $\log ft$ value of the ground state to ground state β -transition from ^{35}S is known⁵⁾ to be 5.01 ± 0.02 . If the asymmetry δ in the mass 35 multiplet is taken to be $+15 \pm 10\%$, a value which encompasses the known range, then the value for the ground state β -transition from ^{35}K would be 5.07 ± 0.05 . Based on this estimate, $\log ft$ values can be assigned to all β -transitions from ^{35}K . The resulting values are shown in Table 3 and Fig. 3. These indicate that all transitions with the exception of that to the 2638 keV state are allowed.

The spin-parities of the ground and first excited states of ^{35}Ar have been determined previously⁵⁾ to be $3/2^+$ and $1/2^+$ respectively. The second excited state at 1751 keV has been produced in neutron pickup experiments on ^{36}Ar , and its J^π restricted to $(3/2, 5/2)^+$; a comparison with states in the mirror nucleus ^{35}Cl (see Fig. 4) strongly favours the $5/2^+$ assignment. In that case, the fact that all three states are produced by allowed β -decay from ^{35}K , establishes the J^π of ^{35}K to be $3/2^+$, a result which agrees with the ground state spin of its mirror, $^{35}\text{S}^+$. This in turn restricts the spin-parities of all states observed in ^{35}Ar , except the one at 2638 keV, to be $(1/2, 3/2, 5/2)^+$.

Some further specific remarks are indicated:

The 2638 keV level. Comparison with ^{35}Cl shows two states in that nucleus at about the same energy, one $3/2^+$, the other $7/2^+$. (See Fig. 4.) Superficially, the $\log ft$ value limit shown in Table 3 for the 2638 keV state in ^{35}Ar would suggest

† Further support for a $3/2^+$ assignment comes from the good agreement reported in ref. 6. between the mass excesses of ^{35}K and its analogue state in ^{35}Ar and predictions for $3/2^+$, $T=3/2$ states taken from the quadratic IMME.

that it must be the $7/2^+$ state, but shell-model calculations to be described in the next section predict a high $\log ft$ value for the $3/2^+$ state as well. Endt and van der Leun⁵⁾ have adopted an energy of 2601 keV for the $3/2^+$ state in ^{35}Ar , which would suggest $7/2^+$ for the 2638 keV state, but their choice is based on conflicting evidence⁹⁻¹³⁾ that in some cases⁹⁻¹¹⁾ applies more nearly to the state at 2638 keV or possibly to an unresolved combination of both. The spin of the 2638 keV state must remain undecided at this time.

The 2983 keV level. A level at 2982 ± 10 keV in ^{35}Ar has been observed previously⁵⁾ with $J^\pi = (3/2, 5/2)^+$. In ^{35}Cl , there is a $5/2^+$ state known at 3003 keV. The deexcitation of the lowest $T=3/2$ state in ^{35}Cl is dominated by a γ transition to this state, a property we also find for the 2983 keV state in ^{35}Ar . This prompts the $(5/2)^+$ assignment given in Fig. 3 and Table 3.

The 5573 keV level. The detailed arguments locating and identifying this state as the lowest $T=3/2$ state ($J^\pi = 3/2^+$) in ^{35}Ar have been presented in an earlier report of this work⁶⁾. Its energy is significantly different from that reported in the only previous measurement¹³⁾.

The 7510 and 8395 keV level. The interpretation of the many β -delayed proton groups seen in Fig. 2 is rendered difficult by the numerous accessible states in the final nucleus ^{34}Cl . Considering the similarities in the energy differences between some proton groups and the energy spacing of states in ^{34}Cl one may suggest that two proton groups (Nos. 2 and 3 in Table 2) originate from a level at 7510 keV in ^{35}Ar and populate the ground state and the first excited state in ^{34}Cl . Similar arguments can be made for a proton emitting level at 8395 keV in ^{35}Ar based on three proton groups (Nos. 6, 7 and 8 in Table 2) feeding the three lowest states in ^{34}Cl . An excited state near 7510 keV has previously been reported but none has been seen near 8395 keV.

5. DISCUSSION

We have already reported⁶⁾ that the precise value quoted here for the energy of the lowest $T=3/2$ state in ^{35}Ar allows a significant test of the quadratic isobaric multiplet mass equation for the $A=35$ quartet. As with the results for most other multiplets, we find that the coefficient of a possible cubic term, being 4.3 ± 3.6 keV, is very small and consistent with zero.

The energy quoted here for the $T=3/2$ state also agrees much better with the observed systematics of Coulomb displacement energies than the energy reported by Davidson et al¹³⁾. Very good agreement with measured displacement energies in the $1d_{3/2}$ shell has been obtained by Sherr¹⁴⁾ using a parameterized shell model. However, with the excitation energy given by Davidson et al¹³⁾ Sherr found large deviations between experiment and calculation for $T = 3/2$ states in the pairs $^{35}\text{K} - ^{35}\text{Ar}$ and $^{35}\text{Ar} - ^{35}\text{Cl}$. The deviations for the two pairs were +35 and -46 keV, respectively, while the rms deviation for all other nuclides in the $d_{3/2}$ shell was only 6.3 keV. With the excitation energy found in this work for the $T = 3/2$ state in ^{35}Ar a significant improvement is found, the deviations being reduced to +1 and -13 keV.

Shell-model calculations for the low-lying states in $A = 35$ nuclei were performed with the Rochester-Oak Ridge shell-model code¹⁵⁾. All configurations comprising five holes in the $1d_{3/2}$, $2s_{1/2}$ and $1d_{5/2}$ were retained in the calculation with the restriction that not more than three holes be placed in the $1d_{5/2}$ orbit[†]. The one-body and two-body matrix elements of the effective Hamiltonian were taken from the work of Chung and Wildenthal¹⁶⁾, in which the

[†] The restriction, necessitated by computer memory size, is not severe. For example, of the maximum allowed 223 configurations for a $J^\pi=5/2^+$ state, 194 were retained in the present calculation.

realistic interaction of Kuo¹⁷⁾ was systematically adjusted in a least squares fit to 134 measured level energies in the $A = 32-39$ mass region. The calculated ^{35}Ar spectrum is compared in Fig. 4 with the measured levels in the mirror nuclei ^{35}Ar and ^{35}Cl . The agreement in excitation energies is excellent as anticipated, since all ^{35}Cl states shown in the diagram were included in the Chung-Wildenthal fit.

We also show in Fig. 4 the calculated $\log ft$ values obtained for $^{35}\text{K}(\beta^+)^{35}\text{Ar}$ using an unrenormalized single-particle Gamow-Teller operator. Agreement in $\log ft$ values is quite impressive, in keeping with the general success of such calculations in this region of nuclides.

It can be noted that even the non-observation of β -feeding to any levels at ~ 2.6 MeV is quite consistent with the calculations. Although the transition to the $3/2^+$ state calculated at 2.94 MeV is allowed by its spin, the predicted $\log ft$ value is too large - and the transition too weak - for us to have observed it.

The shell-model predictions for other positive parity states in ^{35}Ar are given in Table 4. These give some hints for the identification of states observed above 3.5 MeV:

1) Endt and van der Leun⁵⁾ cite a $1/2^+$ state at 3884 ± 10 keV in ^{35}Ar . This state could well be associated with the second $1/2^+$ state, which the shell model places at 4.37 MeV with a large $\log ft$ of 7.19. Such a weak transition would be consistent with our not observing the state.

2) The excited state at 4065 keV (only tentatively identified by us - see Fig. 3 and Table 3) could be the third $3/2^+$ state, since the shell model locates that state at 3.72 MeV with a $\log ft$ in agreement with our experimental results.

3) The two other states that we observe without definite spin determination, at 4528 and 4786 keV, are likely the fourth $3/2^+$ state and the third $5/2^+$ state, although it is not clear which state is which. Both energies and measured $\log ft$ values are in reasonable agreement with calculation.

4) The observed $1/2^+$ state at 4726 keV with $\log ft = 4.87 \pm 0.13$ is probably the third shell model $1/2^+$ state. Once again, the energy and transition rate both support this correlation.

There is increasing evidence^{18,19)} that the single-particle Gamow-Teller operator when used in finite nuclei should be renormalized downwards (quenched) by some 10 to 20 per cent. This empirical renormalization simulates both the presence of mesonic-exchange currents not included in the shell-model calculations, and the errors introduced by the necessity of treating the many-nucleon system with model-space truncations. Brown, Chung and Wildenthal¹⁹⁾ have determined empirical values of the four single-particle matrix elements of the Gamow-Teller operator between all combinations of sd-shell orbitals in a fit to 54 β -decay transition data in nuclei with $17 \leq A \leq 39$. This fit can be tested, to some extent, in the present work since the decay of ^{35}K was not included in the data set[†].

The transition rates to low-lying states in ^{35}Ar were recomputed with the same wavefunctions as before but with the empirical single particle matrix elements. As anticipated, the theoretical $\log ft$ values for the fastest transitions were increased by 0.2 over the calculations without renormalized operators (Table 4); values for the weak transitions did not change systematically. On balance, these changes make very little difference to the agreement with experiment. Certainly the ^{35}K decay does not provide convincing evidence in favour of the empirical renormalization.

[†]This does not hold true for the ground state transition since we derived it solely from the $^{35}\text{S}(\beta^-)^{35}\text{Cl}$ mirror transition, which was included in the fit.

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FIGURE CAPTIONS

- Figure 1 Spectrum of β -delayed γ -rays from ^{35}K . All peaks assigned to the decay of ^{35}K , i.e. all peaks not identified as originating from room background or from cross contamination by ^{38}K , are marked by arrows. The numbers above the arrows correspond to the numbers given to each γ -transition in Table 1. Single escape peaks are denoted by S, double escape peaks by D and peaks due to coincident summing with annihilation radiation by SA.
- Figure 2 Spectrum of β -delayed protons from ^{35}K .
- Figure 3 Proposed decay scheme of ^{35}K . This decay scheme takes into account 98.8% of the beta strength from ^{35}K . The remaining 1.2%, associated with a γ -ray of 2698 keV, was not placed. The β -feeding of the ground state in ^{35}Ar was not observed in this experiment and, hence, the numbers quoted for this branch were deduced from comparison with the mirror nucleus (see text). Two proton-decaying levels were tentatively placed in the ^{35}Ar level scheme. Our data give evidence for several other proton unstable levels in the same energy region.
- Figure 4 Simplified level schemes of ^{35}Cl and ^{35}Ar compared with a theoretical level scheme obtained from shell model calculations. Mirror states are joined by dashed lines. The figures given above each level are excitation energy in MeV (left), $\log ft$ values in ^{35}K decay (centre) and spin and parity (right).

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Table 1
Gamma Rays from ^{35}K

Peak Number	Energy (keV)	Relative γ -intensity	Peak Number	Energy (keV)	Relative γ -intensity
1	886.8 $\pm$ 0.5	0.9 $\pm$ 0.3	11	2934.5 $\pm$ 0.5	3.5 $\pm$ 0.6
2	1044.4 $\pm$ 0.4	1.3 $\pm$ 0.4	12	2982.68 $\pm$ 0.13 ^{a)}	100 $\pm$ 4
3	1184.0 $\pm$ 0.3	14.3 $\pm$ 0.7	13	3542.0 $\pm$ 0.6	2.9 $\pm$ 0.6
4	1426.8 $\pm$ 0.4	3.0 $\pm$ 0.5	14	3821.7 $\pm$ 0.7	3.5 $\pm$ 0.7
5	1507.4 $\pm$ 0.5	1.9 $\pm$ 0.4	15	4387.2 $\pm$ 0.9	3.5 $\pm$ 0.8
6	1750.5 $\pm$ 0.3	28 $\pm$ 1	16	4527.9 $\pm$ 0.7	2.6 $\pm$ 0.7
7	1798.9 $\pm$ 0.5	3.5 $\pm$ 0.6	17	4724.5 $\pm$ 1.1	1.2 $\pm$ 0.5
8	2589.80 $\pm$ 0.10 ^{a)}	52 $\pm$ 2	18	4785.4 $\pm$ 1.1	1.9 $\pm$ 0.7
9	2638.0 $\pm$ 0.4	5.5 $\pm$ 0.7	19	5572.3 $\pm$ 1.0 ^{b)}	6.1 $\pm$ 1.6
10	2697.7 $\pm$ 0.6	2.3 $\pm$ 0.6			

a) ref. 6

b) The results quoted for this transition were deduced from the analysis of its double escape peak. (See Section 3).

Table 2

Observed Proton Energies and Relative Intensities for the Precursor ^{35}K

Peak Number	$E_p(\text{lab})$ (keV)	Relative Intensity ^{a)}
1	1282 ± 20	16 ± 3
2	1425 ± 20	100 ± 8
3	1555 ± 20	41 ± 5
4	1705 ± 20	42 ± 6
5	1875 ± 20	24 ± 4
6	1980 ± 20	17 ± 3
7	2282 ± 20	23 ± 4
8	2425 ± 20	19 ± 4
9	2575 ± 20	10 ± 3
10	2807 ± 20	5.7 ± 1.8

a) Total proton emission per disintegration of ^{35}K is
 $(3.7 \pm 1.5) \times 10^{-3}$

Table 3

Levels in ^{35}Ar populated in the β -decay of ^{35}K

Excitation Energy (keV)		$J^\pi; T$	Beta Feeding ^{b)} (%)	log <u>ft</u>
this work	previously known ^{a)}			
0		$3/2^+$	$19 \pm 4^c)$	$5.07 \pm 0.05^c)$
1184.0 ± 0.3	1184.2 ± 0.4	$1/2^+$	2.2 ± 0.7	5.78 ± 0.16
1750.6 ± 0.3	1749.8 ± 0.6	$(5/2)^+$	11.9 ± 0.9	4.93 ± 0.08
2637.9 ± 0.3			≤ 0.4	≥ 6.3
$2982.81 \pm 0.13^d)$	2982 ± 10	$(5/2)^+$	26 ± 3	4.29 ± 0.09
$4065.1 \pm 0.4^e)$		$(1/2, 3/2, 5/2)^+$	0.55 ± 0.30	5.67 ± 0.24
4528.2 ± 0.5	4530 ± 10	$(1/2, 3/2, 5/2)^+$	0.7 ± 0.4	5.44 ± 0.27
4725.8 ± 0.6	4721 ± 10	$1/2^+$	2.1 ± 0.4	4.87 ± 0.13
4785.8 ± 1.1	4782 ± 10	$(1/2, 3/2, 5/2)^+$	1.0 ± 0.4	5.20 ± 0.18
$5572.71 \pm 0.17^d)$	5537 ± 25	$3/2^+; 3/2$	36 ± 3	3.34 ± 0.10
$7510 \pm 20^e)$	7502 ± 10	$(1/2, 3/2, 5/2)^+$	0.15 ± 0.06	4.85 ± 0.25
$8395 \pm 20^e)$		$(1/2, 3/2, 5/2)^+$	0.062 ± 0.026	4.60 ± 0.25

a) Ref. 5

b) The unplaced 2698 keV γ -ray could not account for more than 1.2% of β -decay feeding. This has not been incorporated in the table since it is well within quoted uncertainties.

c) Deduced from mirror symmetry (see text).

d) Ref. 6

e) Tentative identification

Table 4

Shell-Model Predictions for the Positive-Parity Spectrum of
 ^{35}Ar and $\log ft$ Values for the ^{35}K β -decay

Excitation. Energy (MeV)	J^π	$\log ft^a$ bare	$\log ft^b$ empirical
0.00	$3/2^+$	4.72	4.99
1.27	$1/2^+$	6.84	7.44
1.55	$5/2^+$	4.75	4.96
2.89	$7/2^+$		
2.94	$3/2^+$	7.14	6.88
3.25	$5/2^+$	4.30	4.54
3.72	$3/2^+$	5.65	5.79
3.81	$9/2^+$		
3.90	$7/2^+$		
4.37	$1/2^+$	7.19	6.78
4.52	$3/2^+$	4.45	4.71
4.65	$5/2^+$	5.45	5.56
4.85	$1/2^+$	4.78	4.95
5.39	$7/2^+$		
5.43	$5/2^+$	4.78	5.14
5.78	$5/2^+$	7.97	7.21
5.87	$3/2^+$	6.12	6.11
5.89	$3/2^+ T=3/2$	3.30	3.30

a) using the bare (unrenormalized) single-particle Gamow-Teller operator

b) using the empirical Gamow-Teller operator from ref. 19

Fig. 1

Fig. 2

Fig. 3

Fig. 4

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