Neutron-Deficient Members of the $A=139$ Decay Chain. II. 4.5-h Pr^{139}

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(Received 28 April 1969)

The γ rays emitted following the decay of 4.5-h Pr^{139} have been investigated with Ge(Li) and NaI(Tl) detectors in singles and anticoincidence configurations. Twelve transitions having the following energies (and relative intensities) were observed: 254.7 (53), 1320.0 (13), 1347.4 (≡100), 1375.7 (33), 1563.6 (9), 1596.6 (10), 1630.6 (70), 1653.3 (8), 1730.2 (1.6), 1818.4 (7.0), 1907.9 (3.5), and 2015.9 keV (3.0). Using energy sums and the anticoincidence results, we placed states in Ce^{139} at 0 ($\frac{3}{2}+$), 254.7 ($\frac{1}{2}+$), 1320.0 ($\frac{3}{2}, \frac{5}{2}, \frac{7}{2}$), 1347.4 ($\frac{7}{2}+$), 1596.6 ($\frac{3}{2}, \frac{5}{2}, \frac{7}{2}$), 1630.6 ($\frac{3}{2}, \frac{5}{2}+$), 1818.4 ($\frac{3}{2}, \frac{5}{2}+$), 1907 ($\frac{3}{2}, \frac{5}{2}+$), 1984.9 ($\frac{3}{2}, \frac{5}{2}+$), and 2015.9 keV ($\frac{3}{2}, \frac{5}{2}, \frac{7}{2}+$). The assignments were made on the basis of log*ft* values and relative photon intensities. The single particle versus collective behavior of the states is also discussed.

I. INTRODUCTION

THE ${}_{59}Pr_{80}{}^{139}$ is twice removed from stability in the $A=139$ decay chain and decays with a 4.5-h $t_{1/2}$ to 140-day Ce^{139}. Pr^{139} was first produced in 1950 by Stover,[1] who bombarded Ce with 20- and 32-MeV p's and attributed a 4.5-h activity to the reaction, $Ce^{140}(p, 2n)Pr^{139}$. Since that time, there have been a number of papers on its decay,[2–9] including two recent, rather complete studies[8,9] in which Ge(Li) detectors were used to observe the γ rays following its decay.

We have just completed an extensive investigation[10] of the decays of Nd^{139m+g}. During the course of that investigation we, of course, observed γ rays from the decay of the daughter Pr^{139}. It was necessary to make careful observations of these γ rays in order to avoid inadvertently confusing them with γ rays in the complex Nd^{139m+g} spectra. This led to our producing Pr^{139} separately from Nd^{139m+g}, and we were able to obtain somewhat more precise and more extensive information than that which had been published already. Thus, we found it worthwhile to investigate the Pr^{139} γ rays more completely. To date, very little has been published on the interpretation of the states in ${}_{58}Ce_{81}{}^{139}$ (closed $g_{7/2}$ proton subshell, one neutron hole in the $N=82$ shell). Therefore, we here present a discussion of the structures of the states in terms of the shell model and in relation to states in other nuclei in this region.

II. SOURCE PREPARATION

We prepared Pr^{139} sources by bombarding reagent grade $CeNO_3$ (88.5% Ce^{140}, 11.07% Ce^{142}, 0.250% Ce^{138}, and 0.193% Ce^{136}) with 29-MeV p's from the Michigan State University sector-focused cyclotron. Typically, ≈100-mg targets were bombarded with a 1.5-μA beam for ≈1 h. The sources were usually aged some 5 h before starting counting, and at that time the primary activities were Pr^{139}, 17.2-h Ce^{135}, and 19.2-h Pr^{142}, although 19.5-h La^{135}, 33-day Ce^{141}, and 140-day Ce^{139} were also noted as the sources aged. These contaminant activities were so weak that they did not interfere significantly with the measurements on the Pr^{139} decay. The counting was done over a period of several days, with careful attention being given to the growth and decay of the various peaks. In this way, γ rays from the different activities were easily distinguished.

Pr^{139} was also made as a by-product of our Nd^{139m+g} sources[10] through the reaction chain

$$Pr^{141}(p, 3n)Nd^{139m+g} \xrightarrow{\beta^+/\epsilon} Pr^{139}.$$

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† Work supported in part by the U.S. National Science Foundation.

‡ Work supported in part by the U. S. Atomic Energy Commission.

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These sources confirmed some of the Pr^{139} γ rays, but the multitude of high-intensity γ rays from Nd^{139m+g} decay obscured much of the Pr^{139} spectrum.

III. EXPERIMENTAL RESULTS

A. γ-Ray Singles Spectra

A 7-cm^3 five-sided coaxial Ge(Li) detector manufactured in this laboratory[11] was used to obtain singles γ-ray spectra. The detailed methods used, including standards and spectrum analysis, are given in Ref. 10. We show some resulting spectra for the low- and high-energy regions in Figs. 1(a) and 1(b), respectively. A $\frac{5}{8}$-in. graded Pb absorber was employed while recording the high-energy spectrum in order to enhance the weak higher-energy γ rays.

A summary of the Pr^{139} γ-ray energies and intensities measured in this investigation is given in Table I. Each entry is the weighted average of a number of determinations performed at different times and with different electronics. In addition to purely statistical errors, the errors in both the energies and intensities reflect their reproducibilities, peak heights above background, and estimated uncertainties in the standards.[10] Also shown for comparison in Table I are the results of King, Neff, and Taylor[8] and of de Frenne *et al.*,[9] the two recent studies of Pr^{139} decay that used Ge(Li) detectors.

By careful intensity measurements at several different times after bombardment and by the use of graded Pb absorbers to allow the enhancement of the counting rate at high energies, we were able to confirm clearly the presence of the weak 1730.2- and 2015.9-keV γ's, which had been seen by de Frenne *et al.*, but not by King, Neff, and Taylor. We were also able to place an upper limit of 0.5 (relative to 100 for the 1347.4-keV γ intensity) on the intensity of a 1575.7-keV γ that had been reported by King, Neff, and Taylor. In several of our spectra, we did observe a 1575.9-keV γ in this energy region, but this γ ray proved to result from a 19.2-h Pr^{142} contaminant activity produced by the Ce^{142} $(p, n)Pr^{142}$ reaction.

Only the 254.7-, 1347.4-, 1375.8-, and 1630.6-keV γ's from Pr^{139} decay were seen in the Pr^{139} sources produced as decay products from Nd^{139m+g}. The remaining γ rays were either weak enough to be hidden by the intense Nd^{139m} γ rays or corresponded closely to a Nd^{139m} γ ray; e.g., the 254.7-keV γ was obscured at all times by the 254.9-keV γ from Nd^{139m} decay.

B. γ-γ Anticoincidence Study

From the Pr^{139} disintegration energy[6,12] of 2110±20 keV and the measured γ-ray energies of Table I, it is clear that the cascades that are energetically allowed must involved only the 254.7-keV γ. Unfortunately, as can be seen from Fig. 1(a), coincidence experiments gated on this γ ray are not terribly practicable because of its relative weakness and the intense background upon which it rides. However, a γ-γ coincidence was performed by de Frenne *et al.*,[9] in which they gated on all γ rays having energies greater than 1.5 MeV, and this experiment indicated

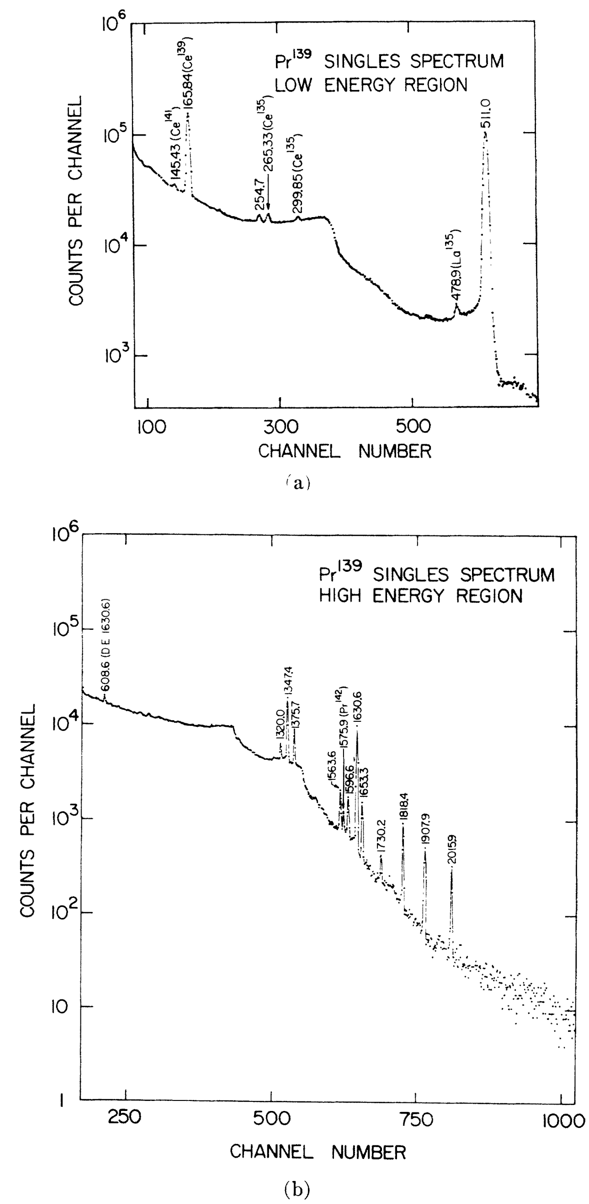

FIG. 1. Pr^{139} singles γ-ray spectrum taken with a 7-cm^3 Ge(Li) detector: (a) low-energy portion; (b) high-energy portion. A $\frac{5}{8}$-in. graded Pb absorber was placed between the source and the detector to lower the low-energy counting rate for spectrum (b).

[11] This detector was constructed by Dr. G. Berzins working with Dr. C. R. Gruhn, to both of whom we express our thanks.

[12] J. H. E. Mattauch, W. Thiele, and A. H. Wapstra, Nucl. Phys. **67**, 1 (1965); **67**, 32 (1965); **67**, 73 (1965).

TABLE I. Pr^{139} γ rays.

Energy (keV) Present work	Energy (keV) King, Neff, and Taylor[a]	Energy (keV) de Frenne *et al.*[b]	Relative intensity Present work	Relative intensity King, Neff, and Taylor[a]	Relative intensity de Frenne *et al.*[b]
254.7 ± 0.3	254.7 ± 0.1	255.15 ± 0.2	53 ± 5	37.7	47 ± 5
$511.0(\gamma^{\pm})$	511.0	511.0	3600 ± 400	3280	4000 ± 200[c]
1320.0 ± 0.3	1320.4 ± 0.4	1320.0 ± 0.5	13 ± 3	7.6	16 ± 3
1347.4 ± 0.2	1347.4 ± 0.2	1346.8 ± 0.5	$\equiv100$	$\equiv100$	100 ± 10
1375.7 ± 0.2	1375.8 ± 0.3	1375.3 ± 0.5	33 ± 2	22.6	25 ± 2
1563.6 ± 0.3	1563.8 ± 0.2	1563.6 ± 0.5	9 ± 2	5.7	9 ± 1
(1576)[d]	1575.7 ± 0.4		<0.5	(2.26)	
1596.6 ± 0.3	1597.5 ± 0.4	1595.6 ± 0.5	10 ± 2	4.5	7 ± 1
1630.6 ± 0.3	1630.6 ± 0.2	1630.7 ± 0.5	70 ± 7	53	65 ± 7
1653.3 ± 0.3	1652.0 ± 0.4	1653.3 ± 0.5	8 ± 2	5.3	7 ± 1
1730.2 ± 0.4		1729.8 ± 0.9	1.6 ± 0.5		1.5 ± 0.5
1818.4 ± 0.3	1818 ± 1	1818.0 ± 0.5	7.0 ± 1.0	3.4	6.5 ± 1
1907.9 ± 0.4	1905 ± 1	1907.0 ± 0.9	3.5 ± 0.5	<2	3 ± 1
2015.9 ± 0.5		2015.0 ± 0.9	3.0 ± 0.5		3 ± 1

[a] Reference 8.
[b] Reference 9.
[c] Assuming that the "2000 ± 100" in Fig. 3 of Ref 9 indicates β^+ intensity relative to 100 for the 1347-keV γ ray.
[d] We did not observe a γ ray of this energy and can only place an upper limit on its intensity.

that one or more of these is in cascade with the 254.7-keV γ.

In order to determine which of the 11 higher-energy γ rays are the ones in coincidence with the 254.7-keV γ and to search for additional weak γ rays that might have passed unobserved in other measurements, we employed an 8×8-in. NaI(Tl) split annulus[13] in an anticoincidence experiment with the 7-cm³ Ge(Li) detector. The single-channel gate on the signals from the annulus was chosen to be open for all γ rays having energies greater than 100 keV. Each Pr^{139} source was placed inside the annulus tunnel on top of the Ge(Li) detector, which blocked one end of the tunnel. An additional 3×3-in. NaI(Tl) anticoincidence detector was placed in the tunnel above the sources and the Ge(Li) detector in order to reduce further the sharp Compton edges caused by back-scattering in the Ge(Li) detector.

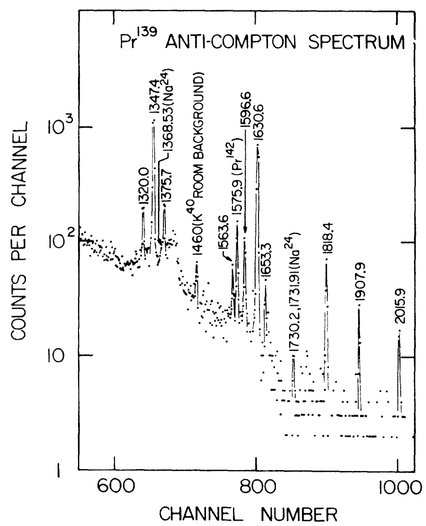

FIG. 2. Pr^{139} anticoincidence spectrum recorded by the 7-cm³ Ge(Li) detector when placed inside the tunnel of an 8×8-in. NaI(Tl) split annulus, with a 3×3-in. NaI(Tl) detector at the other end of the tunnel. For details, see the text or Ref. 13.

The high-energy region of one of the anticoincidence spectra which resulted is shown in Fig. 2. In Table II, we compare the relative intensities of the Pr^{139} γ rays as obtained from singles and anticoincidence data. These intensities are averages taken over several runs

TABLE II. Pr^{139} relative photon intensities in singles and anticoincidence experiments.

Energy (keV)	Relative intensity Singles (S)	Relative intensity Anticoincidence (A)	Intensity ratio A/S
254.7	53 ± 5	18 ± 2	0.34[b]
511.0	3600 ± 400	363 ± 60	0.10[b]
1320.0	13 ± 3	11 ± 1	0.85[c]
1347.4[a]	$\equiv100$	$\equiv100$	1.00[c]
1375.7	33 ± 2	10 ± 1	0.30[b]
1563.6	9 ± 2	4 ± 0.8	0.4[b]
1596.6	10 ± 2	8 ± 1	0.8[c]
1630.6	70 ± 7	72 ± 6	1.0[c]
1653.3	8 ± 2	2 ± 0.3	0.25[b]
1730.2	1.6 ± 0.5	0.5 ± 0.1	0.3[b]
1818.4	7.0 ± 1.0	5.3 ± 0.6	0.8[c]
1907.9	3.5 ± 0.5	2.8 ± 0.3	0.8[c]
2015.9	3.0 ± 0.5	2.6 ± 0.3	0.9[c]

[a] The high intensity of this γ ray suggests that it is a ground-state transition.
[b] The low A/S ratio suggests that these transitions are involved in coincidences.
[c] The high A/S ratio suggests that these transitions are primarily fed by ϵ decay and proceed directly to the ground state.

[13] R. L. Auble, D. B. Beery, G. Berzins, L. M. Beyer, R. C. Etherton, W. H. Kelly, and Wm. C. McHarris, Nucl. Instr. Methods **51**, 61 (1967).

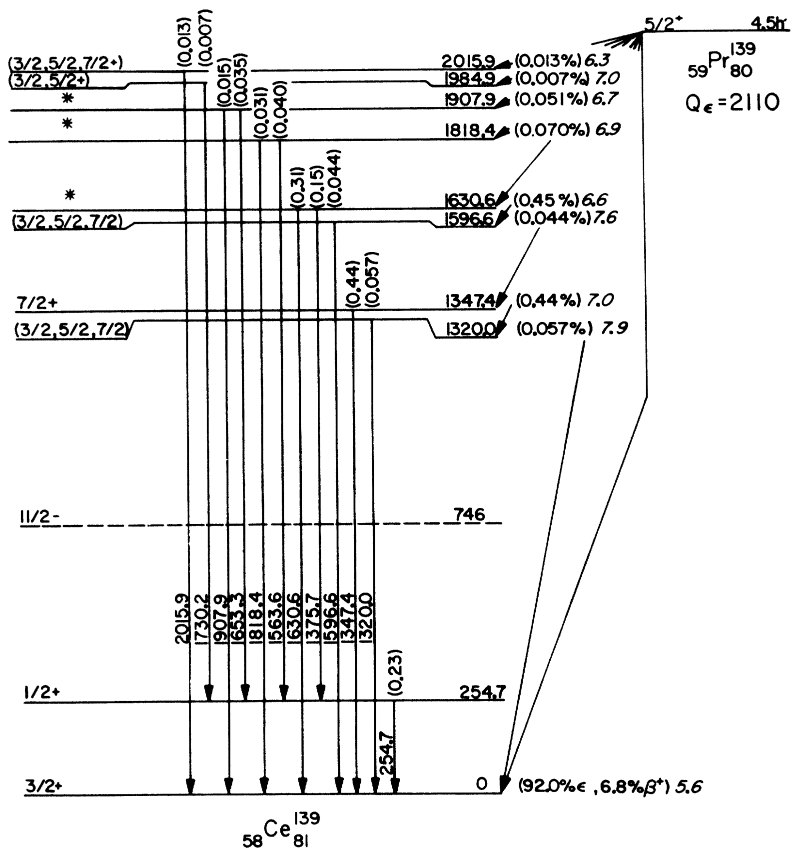

FIG. 3. Pr^{139} decay scheme. Energies are all given in keV and (total) transition intensities are given in percent of the Pr^{139} disintegrations. The β^+/ϵ ratio is a calculated value. The level at 746 keV is the well-known Ce^{139m}, but it is not populated in Pr^{139} decay. The three levels whose spins are designated by asterisks have been assigned $\frac{3}{2}+$ or $\frac{5}{2}+$, but the reader should consult the text for the details concerning these assignments.

recorded at times ranging 1–40 h after bombardment. This procedure was followed to check for underlying contaminant activities with different half-lives. None was observed.

In Table II, column 4, the ground-state γ-ray transitions from states that are primarily ϵ fed are clearly distinguished from the γ rays in cascade with the 254.7-keV γ by their larger anticoincidence/singles intensity ratios.

IV. DECAY SCHEME

The decay scheme that we were able to deduce from the foregoing measurements is shown in Fig. 3. Transition and excited-state energies are given in keV, the disintegration energy coming from the β^+ end point of 1090 ± 20 keV measured by Biryukov *et al.*[6] The β^+/ϵ ratio for decay to the Ce^{139} ground state is a calculated value, using Zweifel's method.[14] Experimental measurements of β^+/ϵ_K have varied widely,[2–6] and, as this is clearly an allowed transition, we have chosen the calculated value because any needed future adjustments could be made quite easily with respect to it. The other transition intensities, both for ϵ decay and for the (total) electromagnetic transitions are adjusted to this value and read in percent of the total Pr^{139} disintegrations. The log*ft* values (in italics on the right-hand sides of the levels) are based on a 4.5-h $t_{1/2}$.

The positions of the levels, with the exception of the 254.7- and 1984.9-keV levels, were indicated unambiguously by the enhancement of their respective ground-state transitions in the anticoincidence spectrum. The levels at 1630.6, 1818.4, and 1907.9 keV were confirmed by the 1375.7-, 1563-, and 1653.3-keV γ's that are in coincidence with the 254.7-keV γ. The adopted energies for these levels is a weighted average based on our relative confidence in the respective cascade and crossover transitions. The 254.7-keV level can, of course, be placed quite confidently on the basis of the coincidence behavior of the 254.7-keV γ. We observed no ground-state transition for the remaining level at 1984.9 keV, but the anticoincidence spectrum demonstrated clearly that the 1730.2-keV γ was in coincidence with a lower-energy γ ray, and the 254.7-keV γ is the only possibility—hence our rationale for placing this level. The 746.0-keV state is the well-characterized[15,16] Ce^{139m}, which, al-

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[16] R. E. Eppley, Wm. C. McHarris, D. B. Beery, and W. H. Kelly (to be published).

TABLE III. Ce^{139} level-scheme comparisons.

Present work		King, Neff, and Taylor[a]		de Frenne *et al.*[b]		$Ce^{140}(d, t)$ [c]	
Energy (keV)	Assignment	Energy (keV)	Assignment	Energy (keV)	Assignment	Energy (keV)	Assignment
0	3/2+	0	3/2+	0	3/2+	0	3/2+
254.7	1/2+	254.7	(1/2)+	255.15	(1/2)+	250	1/2+
[746[d]	11/2−	745[d]	11/2−	746.0[d]	(11/2−)]	750	11/2−
1320.0	(3/2, 5/2, 7/2)	...	...	1320.0	(5/2, 7/2)	...	...
1347.4	7/2+	1347.4	(7/2+)	1346.8	(5/2, 7/2)	1340	7/2+
...	...	1575[e]	...	...	...	...	...
1596.6	(3/2, 5/2, 7/2)	1598	...	1595.6	(5/2, 7/2)	...	...
1630.6	(3/2, 5/2+)	1630.6	...	1630.7	(3/2, 5/2)	...	...
...	...	...	...	1729.8[e]	(5/2, 7/2)[e]	...	...
1818.4	(3/2, 5/2+)	1818	...	1818.0	(3/2, 5/2)	...	...
1907.9	(3/2, 5/2+)	1905	...	1907.0	(3/2, 5/2)	...	...
1984.9	(3/2, 5/2+)	...	...	...	...	...	...
2015.9	(3/2, 5/2, 7/2+)	...	...	2015.0	(5/2, 7/2)	...	...

[a] Reference 8.
[b] Reference 9.
[c] Reference 17.
[d] Ce^{139m}, which is not populated in the decay of Pr^{139}. This has been very well characterized as one of the $N=81$ $M4$ isomers; cf. Refs. 15 and 16.
[e] We consider these levels to have been placed incorrectly.

though not populated by Pr^{139} decay, is included in the decay scheme for completeness.

This decay scheme agrees in most essential features with the decay schemes proposed by King, Neff, and Taylor[8] and by de Frenne *et al.*,[9] but there are a few noteworthy differences. We compare our level placements with those of these groups in Table III; also included are the levels populated by the $Ce^{140}(d, t)Ce^{139}$ reaction.[17] Our anticoincidence data suggest that the 1730.2-keV γ is in coincidence with the 254.7-keV γ, so we have placed a level at 1984.9 keV and removed the one proposed by de Frenne *et al.* at 1729.8 keV. And, as we saw no evidence for the 1575-keV γ (probably from Pr^{142} decay) of King, Neff, and Taylor, in addition to which anticoincidence data indicated the 1320.0-keV γ to be a ground-state transition, we remove their 1575-keV level and place a level at 1320.0 keV, in agreement with de Frenne *et al.* Neither the 1984.9- nor the 2015.9-keV levels had been placed by King, Neff, and Taylor, although de Frenne *et al.* had placed the latter level.

V. DISCUSSION

In Ref. 10, we presented arguments to the effect that the ground state of Pr^{139} has a spin and parity $\frac{5}{2}+$ and that the major component of its wave function is a single $d_{5/2}$ proton outside the $(g_{7/2})^8$ subshell. Now, the Ce^{139} nucleus is one of a chain of odd-mass isotones from ${}_{52}Te_{81}{}^{133}$ to ${}_{64}Gd_{81}{}^{145}$, each of which has a metastable state that deexcites to the ground state via an $M4$ transition.[15,16] These closely related transitions have all been interpreted as $h_{11/2}\rightarrow d_{3/2}$ transitions, as have the corresponding isomeric transitions in the nearby $N=79$ isotones. And the ground-state spins of some of these, e.g., Nd^{141} and Ba^{137} (Refs. 18 and 19), have been measured to be $\frac{3}{2}$ by the atomic beam method. This, together with the smoothly varying energy differences between the isomeric states in the series and the smoothly varying reduced transition probabilities of the $M4$ transitions, strongly suggests that the Ce^{139} ground state is indeed $(d_{3/2})^{-1}$. The fact that 99% of the β decay populates this state directly with a logft of just 5.6 is consistent with the transformation of the $d_{5/2}$ proton into a $d_{3/2}$ neutron. Finally, population of the ground state by the (d, t) reaction[17] also corroborates the $\frac{3}{2}+$ assignment.

We observed no direct population ($\leq 0.01\%$) of the 254.7-keV state, and this is consistent with its being assigned $s_{1/2}$ from the (d, t) reaction. Also, there is a well-known[20] $s_{1/2}$ state at 281 keV in Ba^{137} and, although much less certain, such a state may exist[21] at 195 keV in Nd^{141}. Thus, the intermediate energy in Ce^{139} is consistent with apparent systematics. This $(s_{1/2})^{-1}$ state should differ from the $(d_{3/2})^{-1}$ ground state essentially only in the promotion of an $s_{1/2}$ neutron to the $d_{3/2}$ orbit, so the 254.7-keV γ should be an l-forbidden $M1$ and, as such, may have an observable half-life (a fraction of a nanosecond?) although its low intensity would make such an experiment a difficult one.

The only other state excited to any appreciable extent in the (d, t) reaction was a level at 1340 keV.

[17] R. H. Fulmer, A. L. McCarthy, and B. L. Cohen, Phys. Rev. **128**, 1302 (1962).

[18] S. S. Alpert, B. Burdick, E. Lipworth, and R. Marrus, Bull. Am. Phys. Soc. **7**, 239 (1962).
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[21] I. Gratot, M. Le Pape, J. Olkowsky, and G. Ranc, Nucl. Phys. **13**, 302 (1959).

Because of the nature of this reaction and the rather large spectroscopic factor for populating this state, one can probably assume that it contains most of the $g_{7/2}$ strength. The level we observed at 1347.4 keV corresponds to this state and its deexcitation solely to the $\frac{3}{2}+$ ground state is consistent with such an assignment. The rather large $\log ft = 7.0$ for an allowed transition is easily explained even on simple shell-model terms by the fact that a $d_{5/2}$ proton is being converted to a $g_{7/2}$ neutron; however, the $g_{7/2}$ subshell in the parent is filled, so, in addition, a promotion of a neutron from $g_{7/2}$ to $d_{3/2}$ is required, thus slowing down the transition. There are a number of similar retardations now known.[22]

Assignments for the remaining states are more nebulous. The $\log ft$'s, ranging from 6.3 to 7.9 do not allow one to decide offhand between allowed and first-forbidden nonunique transitions, so spins for these states can be $\frac{3}{2}$, $\frac{5}{2}$, or $\frac{7}{2}$, with either even or odd parity. Owing to the apparent difficulty of constructing so many odd-parity states—it would require coupling the lower states to, say, a 3− vibrational state or the $h_{11/2}$ state to a 2+ vibrational state—most of the higher-lying states probably have even parity. Also, one would expect most allowed capture transitions in this nucleus to be somewhat retarded for reasons very similar to that causing the retardation of the transition to the $\frac{7}{2}+$ 1347.4-keV state.

The spin assignments can be narrowed down for the states that depopulate through the $\frac{1}{2}+$ 254.7-keV state. One has to be careful about making assignments based solely on the γ-ray branching ratios for the following reasons. The Ce^{139} nucleus lies intermediate between Ce^{138} and Ce^{140}, and, although Ce^{138} has a first excited state[23] at 790 keV that appears to be a 2+ quadrupole vibrational state, Ce^{140} has its first excited state[24] at 1596 keV, and this state decays by a nonenhanced $E2$ transition. Several calculations[25,26] on the properties of this Ce^{140} state indicate it to be complicated but essentially a two-quasiparticle state. Thus, because they may be either enhanced or not enhanced, in Ce^{139} one has to be particularly cautious with $E2$ transitions.

The $\frac{7}{2}+$ assignment is excluded for the states at 1630.6, 1818.4, and 1907.9 keV because of the γ-ray branchings from these states to the $\frac{1}{2}+$ 254.7-keV state. The intensities of the transitions from each to the $\frac{3}{2}+$ and $\frac{1}{2}+$ states differ at most by a factor of slightly more than 2. This suggests that the transitions in each pair have similar multipolarities, i.e., both $M1$'s $(+E2$'s) or one $E2$ with the other being largely $E2$ with a small admixture of $M1$. These would be consistent with the assignment of $\frac{3}{2}+$ or $\frac{5}{2}+$ to these three states. (The γ-ray branchings would also be consistent with all γ transitions being $E1$'s, implying $\frac{3}{2}-$ for the states. See our previous remarks, however, concerning the parities of the states.) One is tempted to try to use the core-coupling model to justify the $\frac{3}{2}+$ over the $\frac{5}{2}+$ assignment. However, the states and transitions can be explained almost equally well by a configuration that is primarily $s_{1/2}$ coupled to a 2+ core, primarily $d_{3/2}$ coupled to a 2+ core, or an intermediate mixture of both $s_{1/2}$ and $d_{3/2}$ coupled to the 2+ core. And, although tempting, at this point, it is not possible to make a clear distinction between $\frac{3}{2}+$ and $\frac{5}{2}+$ for the states.

The state at 1984.9 keV is tentatively assigned $\frac{3}{2}+$ or $\frac{5}{2}+$ on the basis of its single transition to the $\frac{1}{2}+$ 254.7-keV state. (The same remarks on parity apply as before.)

As of now, not much information can be gleaned from a comparison of the trends of states either in the Ce isotopes with $N<82$ or in the $N=81$ isotones because so little is known about states in these nuclides. The states in Ce^{139}, however, should prove useful in helping to interpret the properties of states in other nuclides in this region when more such states become known.

ACKNOWLEDGMENTS

We thank Dr. W. P. Johnson and H. Hilbert for their aid explaining the fine points and helping us operate the Michigan State University Cyclotron. We also thank Mrs. Carolee Merritt for helping with the computer programs and data analysis.

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