PHYSICAL REVIEW C VOLUME 11, NUMBER 4 APRIL 1975

Radioactive decay of 30-h $^{131}Te^m$ and 25-min $^{131}Te^g$ to levels of ^{131}I†

S. V. Jackson* and W. B. Walters‡
Department of Chemistry, University of Maryland, College Park, Maryland 20742 §

R. A. Meyer
Lawrence Livermore Laboratory, Livermore, California 94550 ¶
(Received 4 November 1974)

High-resolution Ge(Li) detectors have been used to observe γ-ray singles and coincidence spectra of 30-h $11/2^-$ $^{131}Te^m$ and of 25-min $3/2^+$ $^{131}Te^g$. Sources were produced by neutron irradiation of enriched ^{130}Te metal, and, in the case of $^{131}Te^m$, were chemically purified to remove the ^{131}I daughter. A total of 190 and 80 γ rays are attributed to the decays of $^{131}Te^m$ and $^{131}Te^g$, respectively; and 174 and 77 of these transitions have been placed in a ^{131}I level scheme involving 52 excited states. The β feeding from the $11/2^-$ $^{131}Te^m$ to the $7/2^+$ ^{131}I ground state was determined to be $(5.2 \pm 3.0)\%$ ($\log f_1 t = 10.5$). The isomeric transition branch of $11/2^-$ $^{131}Te^m$ to $3/2^+$ $^{131}Te^g$ was determined to be $(22.2 \pm 1.6)\%$. The 6-nsec isomer in ^{131}I at 1797 keV has been assigned as $15/2^-$ and interpreted as a $\pi\nu_1\nu_2$ three quasiparticle state. The level structure of ^{131}I is interpreted in terms of the shell model and core excitation considerations.

[RADIOACTIVITY $^{131}Te^m$, $^{131}Te^g$ [from ^{130}Te (n,γ)]; measured E_γ, I_γ, γ-γ coin; deduced logft, IT branch. ^{131}I deduced levels, J, π. Enriched target; Ge(Li) detectors.]

I. INTRODUCTION

The iodine nuclei, with three protons beyond the closed shell at $Z=50$ and neutron number approaching the closed shell at $N=82$, offer the opportunity to examine the structure of nuclei with limited seniority. There has been much recent experimental work on the level structures of ^{127}I and ^{129}I including the study of the decay of $^{127}Te^{m+g}$ by Apt, Walters, and Gordon,[1,2] the $^{129}Te^{m+g}$ decay study of Mann, Meyer, and Walters,[3,4] the γ-ray angular correlation study (^{129}I) of DeRaedt, Rots, and Van de Voorde,[5] and the ($^3He,d$) reaction work of Auble, Ball, and Fulmer.[6] In addition, there have been several recent theoretical papers dealing with single particle plus phonon[7] and three quasiparticle plus phonon[8-11] states near the $Z=50$ closed shell. The decays of $^{131}Te^m$ and $^{131}Te^g$ to levels in ^{131}I are of particular interest, as the increased Q_β (from ^{127}Te and ^{129}Te) should allow the observation of additional levels as well as extend the systematics of the level structures of the neutron excess I isotopes. The systematics of the energy levels and the γ-ray branchings should then provide a valuable check on the theoretical work.

The structure of the high-spin ($\geq\frac{7}{2}$) excited states of ^{131}I observed in the decay of 30-h $\frac{11}{2}^-$ $^{131}Te^m$ was first studied by Hebb[12] and by Badescu *et al.*[13,14] More recent studies, employing Ge(Li) detectors and Ge(Li)-NaI(Tl) coincidence spectrometers, were performed by Devare, Singru, and Devare[15] and by Beyer, Berzins, and Kelly.[16] The multipolarities of several of the transitions were established by studies[15,17] of the internal conversion electron spectrum of $^{131}Te^m$. Two isomeric states have been observed in ^{131}I, one at 149.7 keV and the other at 1797 keV, with half-lives of 0.75-nsec[18] and 6.0-nsec,[15,19] respectively. In addition, the g factors of these two states were measured and found to be +1.11 and −0.16, respectively.[20] The resulting decay scheme for $^{131}Te^m$, however, contained many ambiguities as to spin and parity assignments of the ^{131}I levels. We therefore initiated a study of the decay of 30-h $\frac{11}{2}^-$ $^{131}Te^m$ for the purpose of elucidating the high-spin level structure of ^{131}I. Preliminary reports of this work have been given.[21,22]

The structure of the low-spin ($\leq\frac{5}{2}$) excited states of ^{131}I seen in the decay of 25-min $\frac{3}{2}^+$ $^{131}Te^g$ has been studied in detail by Walters, Bemis, and Gordon[23] and by Macias and Walters.[18] In addition, these levels have been studied using the ($^3He,d$) reaction on ^{130}Te by Auble, Ball, and Fulmer.[6] During the course of our experiments on the decay of 30-h $^{131}Te^m$ we found it useful to reinvestigate the decay of 25-min $^{131}Te^g$ to aid in the assignment of weak γ rays and to reduce the uncertainties in the measured β, γ, and isomeric transition (IT) branches.

II. EXPERIMENTAL PROCEDURE

The sources of $^{131}Te^m$ were produced by irradiating 10–50 mg of tellurium metal obtained from Iso-

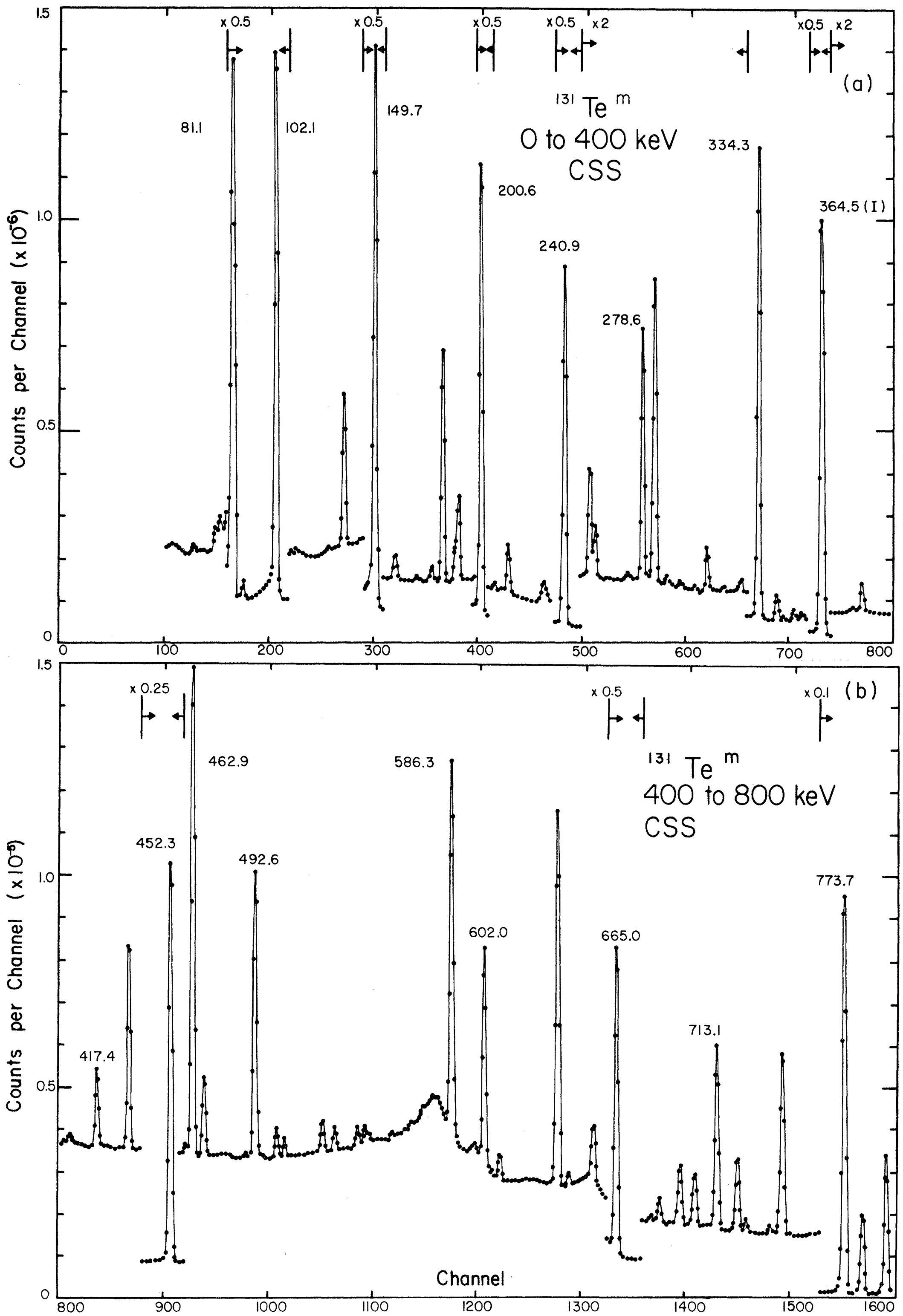

FIG. 1. (a) Compton supressed γ-ray spectrum (CSS) between 0 and 400 keV. (b) Compton supressed γ-ray spectrum between 400 and 800 keV. (c) Compton supressed γ-ray spectrum between 800 and 1200 keV. (d) Compton supressed γ-ray spectrum between 1200 and 1600 keV. (e) Compton supressed γ-ray spectrum between 1600 and 2000 keV and γ-ray spectrum from 19 cm^3 detector between 1600 and 2400 keV.

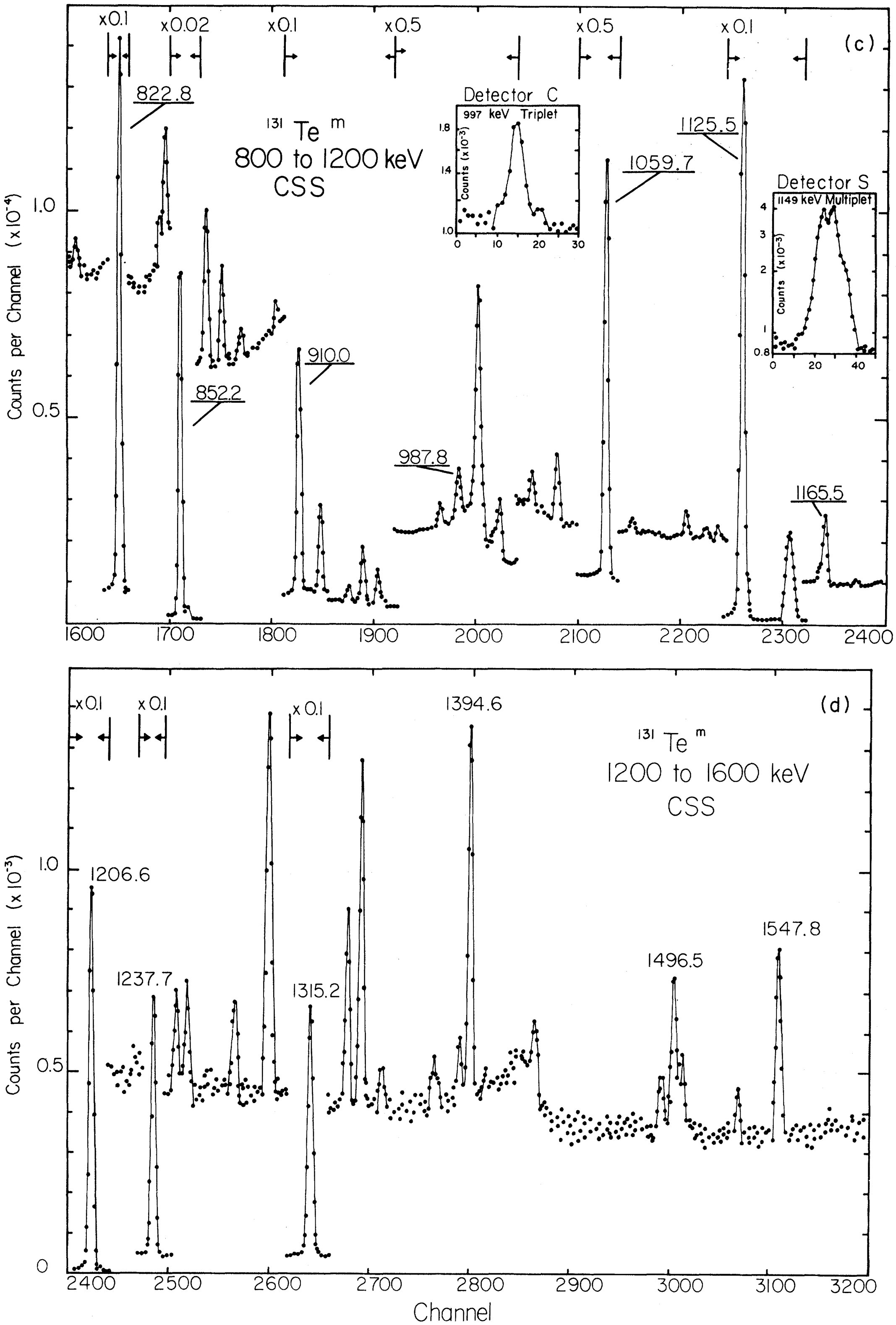

FIG. 1 *(Continued)*

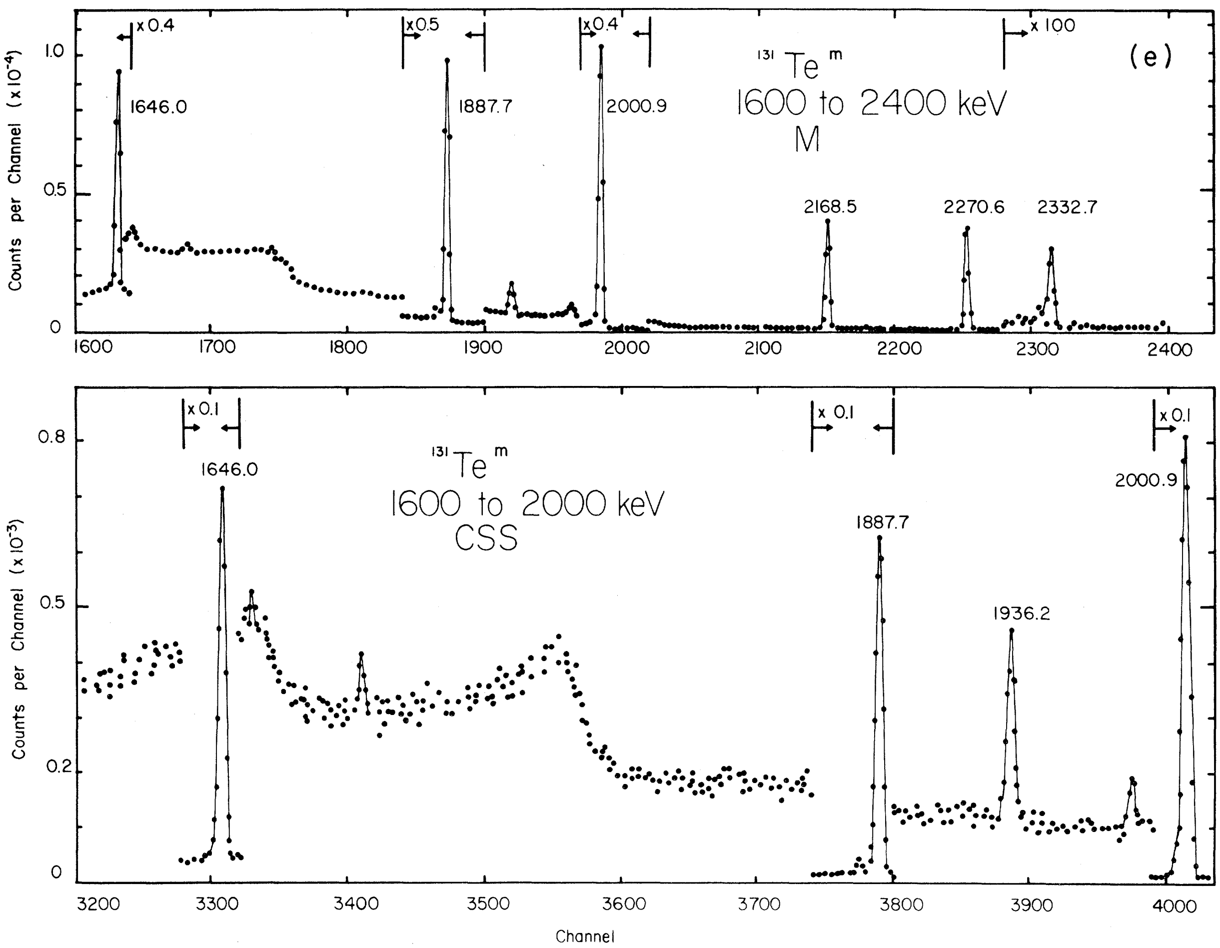

FIG. 1 *(Continued)*

topes Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee, enriched to 99.5% ^{130}Te for several hours in either the Livermore pool-type reactor or the National Bureau of Standards reactor. The sources were allowed to decay for several hours until the 25-min ^{131}Te^g was in transient equilibrium with the 30-h ^{131}Te^m. A chemical separation was then performed to remove the large amounts of daughter ^{131}I present.

Direct γ-ray spectra were observed using a large variety of detector-pulse-height analyzer systems at the Lawrence Livermore Laboratory (LLL) and at the University of Maryland (UM). These included a 0.6-cm^3 Ge(Li) x-ray detector with a full width at half-maximum (FWHM) value of 480 eV at 60 keV as well as a large number of Ge(Li) detectors ranging in size from 7 cm^3 to 65 cm^3 and in FWHM from 1.9 keV to 2.4 keV for the 1332-keV ^{60}Co γ ray. In addition, extensive use was made of the Livermore Compton suppression spectrometer[24] which consists of a 7-cm^3 Ge(Li) detector (FWHM of 2.0 keV at 1332 keV) and a NaI(Tl) anti-Compton annulus consisting of two 23 cm by 33 cm NaI(Tl) crystals. Spectra were taken through various absorbers, including 0.63 cm of Al, 1.27 cm of Pb, and 2.54 cm of Pb; and counting times ranged from ≈1 h to ≈62 h. The spectra were analyzed using the LLL spectrum analysis computer code GAMANAL.[25]

The $\gamma\gamma$-coincidence measurements were carried out at UM using two large volume true-coaxial Ge(Li) detectors (55 cm^3 and 65 cm^3, both having a FWHM of 2.1 keV at 1332 keV) in conjunction with a multiparameter pulse-height analyzer and associated electronics described elsewhere.[2] The coincidence time gate was approximately 30 nsec, and the coincidence events were recorded on magnetic tape in an 8192 by 8192 channel format for later analysis.

Sources of ^{131}Te^g were produced by neutron irradiation of ^{130}Te in the LLL pool-type reactor. Large samples (≥50 mg) and short irradiation

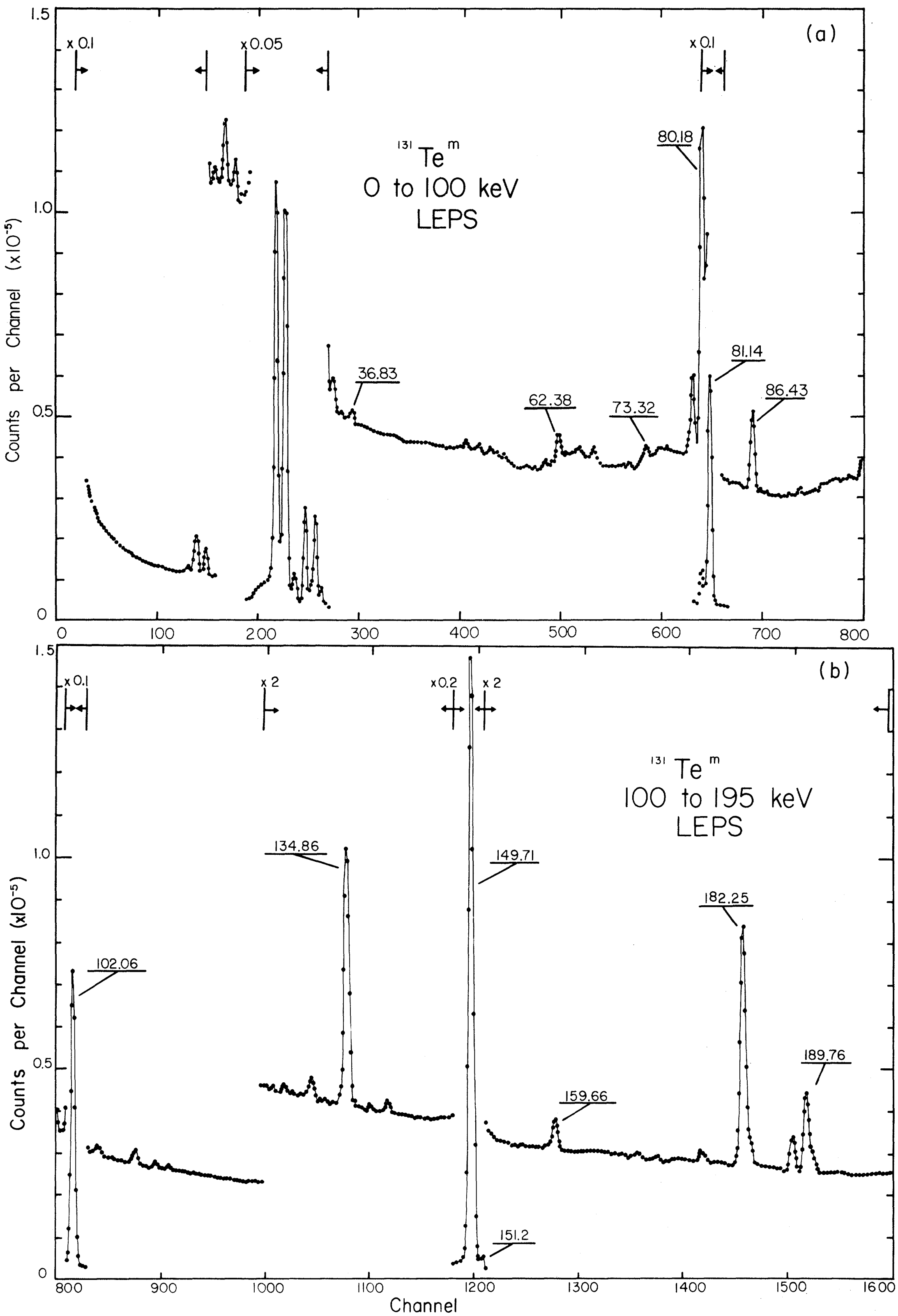

FIG. 2. (a) γ-ray spectrum between 9 and 100 keV observed with the 0.6 cm^3 x-ray detector. (b) γ-ray spectrum between 100 and 195 keV observed with the 0.6 cm^3 x-ray detector.

TABLE I. γ rays observed in the decay of 30-h $\frac{11}{2}^-$ $^{131}Te^m$. The notes in the table mean the following: T—the relative intensity value is that measured for the total peak; G—the relative intensity value is the contribution to the peak from $^{131}Te^g$ decay. The value is calculated based on the 997.16-keV transition being a pure $^{131}Te^g$ γ ray and using the relative intensity values for $^{131}Te^g$ decay from this work; M—the relative intensity value is the result of subtracting the contribution to the peak from $^{131}Te^g$ decay; N—the contribution to the intensity from a transition in $^{131}Te^g$ decay was negligible; MF—the relative intensity value is the result of balancing input to the level and output from the level and assuming no direct β feeding to the level; 125*m*, etc.—the decay of this Te isotope may contribute to the intensity of this peak; Q—the presence of this transition is in some doubt. Generally this is a weak peak with large uncertainty and may not have been observed in all of the singles spectra; D—this transition is possibly a doublet; GG—this transition was observed solely in γ-γ coincidence spectra; IT—this is the internal transition 131*m* to 131*g*. The relative intensity value is calculated from the measured IT branch and the theoretical conversion coefficients; MD—the relative intensity value is the result of subtracting the contribution from $^{131}Te^g$ decay; however, the placement of this transition is different from the placement in $^{131}Te^g$ decay; X—coincidence information supports the assignment of this transition either into or out of the level at 1148.9 keV; 131-I—an ^{131}I γ ray of this energy may contribute to the relative intensity; DG—the relative intensity is the result of subtracting the contribution of an unresolvable transition seen only in coincidence spectra; DE—the relative intensity value has been corrected for the contribution from a double escape peak.

Energy [a] (keV)	Intensity [a, b]	Note	Transition [c] (from/to)	Coincident γ rays in $^{131}Te^m$ decay or identification [d]
16.2 (1)				Ge x-ray escape peak
17.3 (1)				Ge x-ray escape peak
17.6 (1)				Ge x-ray escape peak
18.4 (1)				Ge x-ray escape peak
18.7 (1)				Ge x-ray escape peak
19.6 (1)				Ge x-ray escape peak
19.9 (1)				Ge x-ray escape peak
21.1 (1)				Ge x-ray escape peak
21.8 (1)				Ge x-ray escape peak
22.4 (1)				Ge x-ray escape peak
23.1 (1)				Ge x-ray escape peak
23.7 (1)				Ge x-ray escape peak
24.5 (1)				Ge x-ray escape peak
27.2 (1)				Te x ray
27.5 (1)				Te x ray
28.3 (1)				I x ray
28.6 (1)				I x ray
29.5 (1)				Xe x ray
29.8 (1)				Xe x ray
31.0 (1)				Te x ray
31.7 (1)				Te x ray
32.3 (1)				I x ray
33.0 (1)				I x ray
33.6 (1)				Xe x ray
34.4 (1)				Xe x ray
35.55 (8)				$^{125}Te^m$
36.83 (3)	0.31 (4)		(1924/1887)	
51.00 (5)	0.16 (4)		(1697/1646)	
52.59 (6)	0.14 (4)			Not placed
54.1 (1)	0.03 (2)		1059/1005	
55.8 (1)	0.07 (3)			Not placed
57.50 (7)				^{127}Te
60.84 (7)	0.15 (4)			Not placed
62.38 (2)	0.94 (6)		(2063/2001)	
63.2 (1)	0.11 (4)			Not placed
65.05 (8)	0.21 (5)		(2001/1936)	
66.95 (5)	0.6 (1)			Not placed
68.8 (1)				Au x ray
70.3 (1)				Ge x-ray escape peak
71.2 (1)				Ge x-ray escape peak
72.8 (1)				Pb x ray
73.32 (5)	0.69 (8)		(2241/2168)	
75.0 (1)				Pb x ray

TABLE I *(Continued)*

Energy[a] (keV)	Intensity[a,b]	Note	Transition[c] (from/to)	Coincident γ rays in $^{131}Te^{m}$ decay or identification[d]
78.57 (8)	0.40 (8)		852/773	
79.19 (3)	3.3 (1)		2011/1931	134, 335
80.18 (2)				^{131}I[23.6]
81.14 (2)	105 (2)		1980/1899	102, 149.7, 151, 188, 190, 200, 240, 253, 342, 744, 773, 782, 793, 822, 852, 1023, 1125, 1646
84.9 (1)				Pb x ray
86.43 (2)	3.8 (1)		2011/1924	149.7, 278, 773, 1150
87.3 (1)				Pb x ray
92.2 (1)				Ge x-ray escape peak
95.00(12)	0.10 (5)			Not placed
96.4 (2)	0.15 (6)			Not placed
98.3 (1)	0.35 (8)		1646/1547	
100.0 (1)	1.9 (1)		1980/1880	
101.6 (3)	4.4 (4)		2001/1899	102
102.06 (1)	205 (4)		1899/1797	81, 101, 111, 149.7, 151, 200, 240, 744, 773, 782, 793, 822, 852, 1023
103.3 (3)	1.2 (2)		(2114/2011)	
105.0 (2)	0.7 (1)		(2168/2063)	
109.4 (2)	1.3 (1)	T, 125*m*		$^{131}Te^{g}$, $^{131}Te^{m}$, $^{125}Te^{m}$
	0.4 (1)	G		$^{131}Te^{g}$ [602/492]
	0.9 (2)	M, 125*m*		$^{131}Te^{m}$, $^{125}Te^{m}$
	0.2 (1)	MF	602/492	492
111.9 (2)	0.8 (2)		2011/1899	102, 342
113.5 (1)	0.3 (1)		2011/1887	
123.7 (5)	0.10 (5)	Q		Not placed
125.2 (3)	0.22 (8)	Q		Not placed
126.1 (3)	0.15 (8)		1887/1761	
127.4 (4)	0.6 (2)		(1924/1797)	
130.5 (1)	1.8 (2)	D		Not placed
132.2 (1)	0.12 (8)	Q		Not placed
134.86 (2)	18.3 (6)		1931/1797	79, 182, 200, 240, 744, 773, 782, 822, 852
137.6 (2)	2 (1)		1899/1761	
139.8 (1)				Ge x-ray escape peak
149.3 (3)	2.0 (5)	GG	1697/1547	283, 773, 774
149.71 (1)	533 (5)	T		$^{131}Te^{g}$, $^{131}Te^{m}$
	402 (12)	G		$^{131}Te^{g}$ [149/gs]
	131 (17)	M		$^{131}Te^{m}$
	125 (6)	MF	149/gs	81, 86, 102, 151, 189, 200, 253, 255, 278, 309, 334, 342, 351, 354, 364, 452, 462, 586, 609, 665, 685, 702, 713, 744, 793, 852, 856, 865, 910, 920, 941, 995, 999, 1127, 1148, 1165, 1254, 1333, 1496
151.2 (2)	3.0 (4)	T		$^{131}Te^{g}$, $^{131}Te^{m}$
	1.0 (4)	G		$^{131}Te^{g}$ [1298/1146]
	2.0 (8)	MD	1797/1646	81, 102, 149.7, 183, 586, 793, 852, 1646
155.9 (2)	1.0 (6)		(2270/2114)	
159.66 (4)	3.3 (4)	123*m*	2170/2011	$^{123}Te^{m}$: 213, 364, 793, 1237, 1646
169.7 (2)	0.8 (2)		2170/2001	1148, 2001
172.0 (2)	0.3 (1)			Not placed
177.2 (2)	1.7 (3)	131-I	(1974/1797)	^{131}I[2.68]:
182.25 (2)	41 (4)	T		$^{131}Te^{m}$
	20 (4)	IT		Internal transition
182.25 (2)	19 (5)	GG	2114/1931	134, 200, 240, 335, 375, 773, 822

TABLE I (*Continued*)

Energy[a] (keV)	Intensity[a,b]	Note	Transition[c] (from/to)	Coincident γ rays in $^{131}Te^m$ decay or identification[d]
183.11 (8)	4.0 (5)		1980/1797	151, 200, 240, 744, 773, 782, 822, 852
188.13 (5)	5.5 (3)		2168/1980	81, 283, 334, 773, 793, 852, 910, 1059, 1127, 1206
189.76 (4)	13 (1)		2114/1924	149.7, 278, 773, 793, 865, 1150, 1646, 1887,
190.52 (6)	3.0 (4)		2170/1980	81, 283, 334, 773, 793, 852, 910, 1059, 1127, 1206
200.63 (2)	195 (3)		1797/1596	81, 102, 134, 149.7, 182, 183, 213, 744, 773, 822, 852
203.4 (4)	0.5 (2)	Q	(2001/1797)	
207.5 (1)	1.0 (3)		1059/852	852
210.3 (3)	0.4 (1)			Not placed
211.9 (4)	0.3 (1)	Q, 121*m*	(1974/1761)	
213.98 (3)	11.0 (5)		2011/1797	159, 200, 230, 240, 744, 773, 782, 822, 852
227.7 (4)	0.4 (3)	Q	(1924/1697)	
230.65 (5)	5.0 (3)		2241/2011	213, 364, 773, 793, 1237, 1646
232.3 (1)	2.4 (3)		2168/1936	1333, 1936
235.0 (2)	0.4 (3)	Q	(2170/1936)	
240.93 (1)	196 (2)		1797/1556	81, 102, 134, 182, 183, 213, 773, 782
253.17 (2)	16.8 (3)		1899/1646	81, 149.7, 586, 793, 852, 910, 1059, 1646
255.44 (7)	8.0 (3)		1315/1059	149.7, 665, 910, 1059
261.4 (2)	0.4 (1)		2241/1980	
267.2 (3)	0.4 (3)	Q, N	(2241/1974)	
269.2 (3)	2.8 (6)		(2168/1899) or (1646/1376)	
272.4 (3)				^{131}I[0.56]
278.56 (2)	46.5 (9)	T		$^{131}Te^m$, $^{131}Te^g$
	0.6 (1)	G		$^{131}Te^g$ [1427/1148]
278.56 (2)	46 (1)	MD	1924/1646	86, 149.7, 189, 345, 586, 793, 852, 910, 1059, 1646
281.4 (3)	0.9 (5)		2168/1887	1887
283.2 (2)	10 (1)		1980/1697	149.3, 188, 190, 844, 852, 923
284.30 (8)				^{131}I[61.5]
290.3 (2)	2.0 (3)		2270/1980	
296.8 (3)	1.3 (2)	X	1148/852	852
298.8 (2)	0.6 (4)	T		$^{131}Te^g$ [1444/1146]: $^{131}Te^g$ [1800/1500]
	0.6 (1)	G		$^{131}Te^g$ [1444/1146]: $^{131}Te^g$ [1800/1500]
302.7 (2)	1.0 (3)	131-I, GG	1899/1596	^{131}I[0.045]: 822
303.9 (2)	1.0 (2)		2001/1697	
309.47 (6)	9.7 (9)		1315/1005	149.7, 665, 856, 1005
317.9 (1)				^{131}I[0.79]
323.7 (4)	0.4 (2)			Not placed
324.8 (2)				^{131}I[0.22]
325.8 (2)				^{131}I[2.49]
331.2 (6)	0.8 (3)		1646/1315	
334.27 (1)	247 (3)		1980/1646	149.7, 188, 190, 586, 702, 773, 793, 852, 872, 910, 1059, 1646
335.44 (7)	3.5 (6)		1931/1596	79, 182, 744, 822
342.92 (5)	14 (2)	T		$^{131}Te^m$, $^{131}Te^g$
	4 (1)	G		$^{131}Te^g$ [492/149]
	0 (2)	MF	492/149	149.7
342.92 (5)	10 (3)	GG, MD	1899/1556	81, 111, 773, 792
345.9 (3)	2.5 (8)	N	2270/1924	278, 1150
351.3 (1)	5.4 (5)	N	1899/1547	149.7, 695, 773, 774, 852

TABLE I *(Continued)*

Energy[a] (keV)	Intensity[a, b]	Note	Transition[c] (from/to)	Coincident γ rays in $^{131}Te^m$ decay or identification[d]
353.5 (3)	2.1 (8)	T		$^{131}Te^m$, $^{131}Te^g$
	0.1 (1)	G		$^{131}Te^g$ [1500/1146]
	2.0 (9)	MD	2241/1887	1887
354.7 (1)	5.9 (3)		2001/1646	149.7, 793, 852, 1646
357.4 (3)	0.5 (2)		(1980/1622)	
362.3 (4)	2 (1)	Q	1646/1284	
364.48 (2)				^{131}I[806]
364.98(10)	31 (4)	GG	2011/1646	149.7, 159, 230, 586, 702, 773, 793, 852, 910, 1059, 1646
375.8 (3)	0.3 (1)		1931/1556	182
377.8 (3)	1.0 (7)	Q	(1974/1596) or (2001/1622)	
379.3 (3)	0.5 (2)		2176/1797	
383.90 (7)	10.4 (5)	T		$^{131}Te^m$, $^{131}Te^g$
	5.2 (3)	G		$^{131}Te^g$ [876/492]
	5.2 (8)	MD	1980/1596	744, 773, 822, 852
401.5 (5)	0.10 (5)	T		$^{131}Te^g$ [1500/1098]
	0.06 (9)	G		$^{131}Te^g$ [1500/1098]
403.3 (4)	0.8 (3)	N	1005/602	
404.5 (2)				^{131}I[0.56]
408.2 (3)	1.6 (8)	Q	2332/1924	
417.4 (2)	7.2 (5)	127	2063/1646	586, 793, 852, 1646
421.8 (5)	0.2 (1)	T		$^{131}Te^g$ [1427/1005]
	0.2 (1)	G		$^{131}Te^g$ [1427/1005]
432.40 (7)	17.1 (7)		1980/1547	695, 773, 774, 852, 1547
452.30 (4)	147 (3)	T		$^{131}Te^m$, $^{131}Te^g$
	107 (7)	G		$^{131}Te^g$ [602/149]
	40 (10)	M		$^{131}Te^m$
	33 (2)	MF	602/149	149.7, 546, 665, 685, 713, 1333
462.92 (5)	47 (1)		1315/852	149.7, 609, 665, 685, 702, 852
468.16 (9)	8.1 (8)		2114/1646	793, 852, 1646
492.65 (5)	30 (1)	T		$^{131}Te^m$, $^{131}Te^g$
	28 (3)	G		$^{131}Te^g$ [492/gs]
	2 (4)	M		$^{131}Te^m$
	0.2 (1)	MF	492/gs	109
503.0 (1)				^{131}I[3.58]
506.8 (2)	2.3 (4)			Not placed
524.8 (1)	3.5 (4)		2170/1646	793
530.7 (1)	2.7 (5)		2176/1646	793
541.4 (1)	2.9 (6)		1315/773	665
544.8 (2)	3.0 (7)	T		$^{131}Te^g$ [1146/602]
	2.5 (3)	G		$^{131}Te^g$ [1146/602]
546.7 (2)	1.0 (2)	X	1148/602	452, 602
551.1 (4)	0.10 (8)	T		$^{131}Te^g$ [1427/876]
	0.11(10)	G		$^{131}Te^g$ [1427/876]
558.1 (2)	0.6 (2)		(2114/1556)	
567.2 (3)	0.6 (3)	T		$^{131}Te^g$ [1444/876]
	0.6 (1)	G		$^{131}Te^g$ [1444/876]
572.7 (2)	1.3 (4)	T		$^{131}Te^m$, $^{131}Te^g$
	0.2 (2)	G		$^{131}Te^g$ [1427/852]
	1.1 (6)	MD	1887/1315	
579.8 (3)	2.0 (6)		2176/1596	
586.30 (3)	51 (2)		1646/1059	149.7, 151, 253, 278, 334, 364, 417, 910, 1059
597.0 (2)	1.3 (5)		2001/1403	
602.09 (4)	32 (1)	T		$^{131}Te^m$, $^{131}Te^g$
	24 (2)	G		$^{131}Te^g$ [602/gs]
	8 (3)	M		$^{131}Te^m$

TABLE I (*Continued*)

Energy [a] (keV)	Intensity [a,b]	Note	Transition [c] (from/to)	Coincident γ rays in ^{131}Te^{m} decay or identification [d]
	8 (1)	MF	602/gs	546, 665, 713, 1333
609.4 (1)	3.6 (4)		1924/1315	149.7, 462, 713, 1315
(637.3) (2)	(≤0.8) (8)	131-I	(1697/1059)	^{131}I[72.1]
642.73 (9)				^{131}I[2.18]
654.2 (1)	11 (2)	T		^{131}Te^{g} [1146/492]
	9 (2)	G		^{131}Te^{g} [1146/492]
657.2 (2)	0.8 (4)	Q		Not placed
665.05 (3)	112 (2)		1980/1315	149.7, 255, 309, 452, 462, 541, 602, 702, 713, 852, 856, 910, 1059, 1165, 1315
681.95(30)	0.8 (2)		1284/602	
685.9 (1)	4.0 (3)		2001/1315	149.7, 452, 462, 713, 852, 1315
695.62 (8)	11.2 (6)	T		^{131}Te^{m}, ^{131}Te^{g}
	0.9 (2)	G		^{131}Te^{g} [1298/602]
	10.3 (8)	MD	1547/852	351, 432, 852
702.50 (7)	10.1 (5)	N	852/149	149.7, 334, 364, 462, 665, 744, 793, 1127, 1148
713.10 (4)	37 (4)		1315/602	149.7, 452, 602, 609, 665, 685
722.90 (7)				^{131}I[17.9]
727.0 (2)	3.0 (3)	T		^{131}Te^{g} [876/149]
	2.8 (4)	G		^{131}Te^{g} [876/149]
738.8 (2)	1.7 (3)	X	1887/1148	999, 1148
744.20 (4)	41 (1)	N	1596/852	81, 102, 134, 149.7, 183, 200, 213, 335, 383, 702, 852
749.0 (8)	0.4 (2)	Q	(2063/1315)	
773.67 (3)	1000 (8)	T		^{131}Te^{m} doublet
	986 (10)	DG	773/gs	81, 86, 102, 134, 149.3, 182, 183, 188, 189, 190, 200, 213, 230, 240, 334, 335, 342, 351, 364, 383, 432, 774, 782, 822, 923, 1023, 1114, 1125, 1150, 1206, 1237, 1340, 1394
774.1 (1)	14 (2)	GG	1547/773	149.3, 351, 432, 773
782.49 (4)	201 (3)		1556/773	81, 102, 134, 183, 213, 240, 342, 773
793.75 (3)	358 (5)		1646/852	81, 102, 149.7, 151, 159, 188, 189, 190, 230, 253, 278, 334, 364, 417, 468, 524, 530, 702, 852
801.6 (2)	0.5 (2)		1403/602	
822.78 (4)	158 (2)		1596/773	81, 102, 134, 182, 183, 200, 213, 302, 335, 383, 773
842.1 (2)	1.3 (4)	T		^{131}Te^{g} [1444/602]
	1.2 (2)	G		^{131}Te^{g} [1444/602]
844.9 (2)	4 (1)		1697/852	283, 852
848.9 (2)	1.0 (3)		(1622/773)	
852.21 (3)	543 (6)	T, N		^{131}Te^{m} doublet
	533 (11)	DG, N	852/gs	81, 102, 134, 151, 188, 190, 200, 207, 213, 253, 278, 283, 296, 334, 351, 354, 364, 383, 417, 432, 462, 468, 665, 685, 695, 744, 793, 844, 1035, 1127, 1148, 1211, 1316
852.21 (3)	10 (5)	GG, X	2001/1148	149.7, 999, 1148
856.05 (6)	16 (1)	T		^{131}Te^{m}, ^{131}Te^{g}
	0.5 (1)	G		^{131}Te^{g} [1005/149]
	16 (1)	M	1005/149	149.7, 309, 665, 995
865.1 (2)	5 (1)	DE	1924/1059	DE[1887.70]: 149.7, 189, 910, 1059
872.3 (3)	2.6 (3)		1646/773	334
881.6 (3)	0.9 (3)	N	1887/1005	
898.6 (3)	0.9 (3)	T		^{131}Te^{g} [1500/602]
	0.8 (2)	G		^{131}Te^{g} [1500/602]

TABLE I *(Continued)*

Energy [a] (keV)		Intensity [a, b]		Note	Transition [c] (from/to)	Coincident γ rays in $^{131}Te^m$ decay or identification [d]
910.00	(3)	85	(2)		1059/149	149.7, 188, 190, 253, 255, 278, 334, 364, 586, 665, 865, 920, 941
920.62	(5)	31	(2)		1980/1059	149.7, 910, 1059
923.4	(2)	3.0	(6)		1697/773	283, 773
930.0	(4)	0.5	(3)	Q	1936/1059	
934.5	(1)	4.9	(4)	T		$^{131}Te^g$ [1427/492]
		5.1	(4)	G		$^{131}Te^g$ [1427/492]
941.27	(5)	20.2	(7)		2001/1059	149.7, 910, 1059
948.57	(5)	13.3	(6)	T		$^{131}Te^g$ [1098/149]
		13.2	(6)	G		$^{131}Te^g$ [1098/149]
951.3	(1)	2.0	(4)	T		$^{131}Te^g$ [1444/492]
		1.9	(3)	G		$^{131}Te^g$ [1444/492]
979.0	(1)					DE [2000.94]
987.8	(1)	4.0	(3)		1761/773	
995.1	(3)	2.3	(4)		2001/1005	149.7, 856, 1005
997.16	(6)	19.5	(9)	T		$^{131}Te^g$ [1146/149]
		19.5	(9)	G		$^{131}Te^g$ [1146/149]
999.2	(1)	4.4	(5)	X, N	1148/149	149.7, 738, 852
1003.6	(2)	0.7	(4)	Q	2063/1059	
1005.7	(2)	1.9	(4)	N	1005/gs	309, 995
1007.7	(1)	4.9	(4)	T		$^{131}Te^g$ [1500/492]
		4.8	(3)	G		$^{131}Te^g$ [1500/492]
1023.6	(2)	1.6	(2)		1797/773	81, 102, 773
1027.8	(4)	0.2	(1)	Q	1880/852	
1035.4	(2)	2.7	(2)	N	1887/852	852
1059.69	(4)	40	(1)		1059/gs	188, 190, 253, 255, 278, 334, 364, 586, 665, 865, 920, 941
1072.3	(2)	0.6	(1)		1924/852	
1098.3	(2)	1.1	(2)	T		$^{131}Te^g$ [1098/gs]
		1.1	(2)	G		$^{131}Te^g$ [1098/gs]
1108.3	(3)	0.6	(2)		2168/1059	
1114.1	(3)	0.3	(1)		1887/773	773
1125.46	(4)	295	(6)		1899/773	81, 773
1127.96	(6)	25	(2)		1980/852	149.7, 188, 190, 702, 852
1134.2	(4)	0.2	(1)	Q	1284/149	
1146.97	(6)	30	(3)	T, DE		DE [2168.54]: $^{131}Te^g$ [1146/gs]
		29	(3)	G		$^{131}Te^g$ [1146/gs]
1148.89	(7)	44	(2)	T, N		$^{131}Te^m$ doublet
		39	(8)	DG	2001/852	149.7, 169, 702, 852
1148.89	(7)	5	(6)	GG, X, MF	1148/gs	738, 852
1150.90	(9)	17	(2)		1924/773	86, 189, 345, 773
1162.7	(2)	0.7	(2)		2168/1005	
1165.5	(1)	3.6	(3)		1315/149	149.7, 665
1181.4	(4)	0.3	(2)		2241/1059	
1206.60	(4)	252	(4)		1980/773	188, 190, 773
1211.0	(2)	1.6	(3)		2063/852	852
1227.8	(5)	0.2	(1)	Q	(2001/773) or (1376/149)	
1237.32	(5)	17.0	(8)		2011/773	159, 230, 773
1248.5	(3)					DE [2270.65]
1254.2	(4)	0.7	(1)		1403/149	149.7
1277.7	(3)	0.8	(2)	T		$^{131}Te^g$ [1427/149]
		0.7	(2)	G		$^{131}Te^g$ [1427/149]
1294.47	(7)	2.9	(2)	T		$^{131}Te^g$ [1444/149]
		2.8	(3)	G		$^{131}Te^g$ [1444/149]
1315.16	(8)	20	(1)	T		$^{131}Te^m$ doublet
		18	(2)	DG	1315/gs	609, 665, 685
1316.2	(2)	2.5	(9)	GG	2168/852	852

TABLE I *(Continued)*

Energy [a] (keV)	Intensity [a,b]	Note	Transition [c] (from/to)	Coincident γ rays in $^{131}Te^m$ decay or identification [d]
1318.3 (2)	1.0 (2)		2170/852	
1333.8 (3)	1.4 (2)		1936/602	149.7, 232, 452, 602
1340.6 (1)	2.6 (3)		2114/773	773
1350.9 (4)	0.3 (1)	T		$^{131}Te^g$ [1500/149]
	0.3 (2)	G		$^{131}Te^g$ [1500/149]
1376.8 (4)	1.1 (2)		1376/gs	
1389.6 (3)	0.4 (1)		2241/852	
1394.83 (9)	2.8 (2)		2168/773	773
1403.6 (6)	0.3 (2)		1403/gs	
1426.8 (3)	0.4 (1)	T		$^{131}Te^g$ [1427/gs]
	0.6 (2)	G		$^{131}Te^g$ [1427/gs]
1490.0 (3)				SE[2000.94]
1496.5 (4)	1.5 (2)		1646/149	149.7
1500.4 (2)	0.8 (2)	T		$^{131}Te^g$ [1500/gs]
	0.7 (2)	G		$^{131}Te^g$ [1500/gs]
1527.7 (3)	0.3 (1)	T		$^{131}Te^g$ [1677/149]
	0.3 (1)	G		$^{131}Te^g$ [1677/149]
1547.75 (9)	1.8 (2)	N	1547/gs	432
1556.2 (5)				SUM[773 + 782]
1596.4 (5)				SUM[773 + 822 and 852 + 744]
1646.01 (5)	32 (1)		1646/gs	81, 151, 159, 189, 230, 253, 278, 334, 354, 364, 417, 468
1657.5 (5)				SE[2168.54]
1696.8 (5)	0.4 (1)		1697/gs	283
1759.6 (5)				SE[2270.65]
1830.6 (4)	0.2 (1)	Q	1980/149	
1880.1 (3)	1.6 (2)		1880/gs	
1887.70 (7)	35 (1)		1887/gs	189, 281, 353
1899.1 (5)				SUM[1127 + 852]
1924.1 (3)	0.10 (5)	N	1924/gs	
1936.15 (9)	1.9 (2)		1936/gs	232
1980.3 (3)	0.8 (2)		1980/gs	
2000.94 (6)	52 (1)		2001/gs	169
2168.54 (9)	9.0 (5)		2168/gs	
2270.65 (9)	9.9 (5)		2270/gs	
2332.75(40)	0.07 (1)		2332/gs	

[a] Value shown as 16.2(1) means 16.2 ± 0.1, for example. The uncertainties are one standard deviation.

[b] The intensity values are relative to a value of 1000 for the combined 773-67- and 774.1-keV transitions. To convert to absolute intensities (per 1000 decays) multiply the relative intensity value by 0.3846. This includes the absolute β branch direct to ground of 5.2%. Since this table consists of peaks seen under a wide variety of counting conditions, intensity values are given only for transitions assigned to $^{131}Te^{m+g}$ decay. Transitions not placed in the decay scheme are thought to come from $^{131}Te^m$ decay, as their intensity values were consistent under all counting conditions and they were not observed in $^{131}Te^g$ decay.

[c] Transition assignments are made for $^{131}Te^m$ decay. Assignments in parentheses are dotted in the decay scheme and were placed on the basis of sums and differences and on being consistent with being monopole or dipole transitions. Double assignments are both shown in the decay scheme, with the sums and differences giving no preference for the placement.

[d] Assignments to other Te isotope decays are based on variations in relative intensity values with length of irradiation and with time after irradiation. Assignments to $^{131}Te^g$ decay are based on the present work and on the work of Macias and Walters (Ref. 18). Assignments to ^{131}I decay are based on the work of Meyer, Momyer, and Walters (Ref. 26). On the intensity scale of this table, the most intense ^{131}I γ ray (364.48 keV) had a relative intensity value ranging from about 100 to about 700 depending on the length of the count and the time after chemical separation. For ^{131}I γ rays, the absolute intensity value (per 1000 decays) from the work of Meyer *et al.* (Ref. 26) is given.

TABLE II. γ rays observed in the decay of 25-min $^{131}Te^{g}$.

Energy [a] (keV)	Intensity [a, b]	Note	Transition (from/to)	Energy [a] (keV)	Intensity [a, b]	Note	Transition (from/to)
109.40 (4)	0.9 (1)	c	602/492	852.21 (6)	0.64 (7)	e	852/gs
141.20 (4)	0.41 (7)		1146/1005	853.83 (5)	1.40 (7)		1346/492
149.716 (5)	1000	c	149/gs	856.08 (3)	1.9 (1)	c	1005/149
151.1 (1)	2.5 (9)	c	1298/1146	881.15 (9)	0.37 (6)	c	1757/876
221.57 (5)	0.48 (7)		1098/876	898.54 (3)	2.0 (1)		1500/602
267.5 (3)	0.06 (5)	c	···	934.483 (5)	12.7 (2)		1427/492
274.68 (15)	<0.1		876/602	948.542 (4)	32.8 (4)		1098/149
278.17 (2)	1.43 (7)	c	1427/1148	951.39 (2)	4.8 (1)		1444/492
280.17 (12)	0.25 (7)		1427/1146	997.25 (1)	48.5 (2)		1146/149
294.75 (15)	<0.07		1146/852	999.26 (15)	0.4 (1)	c	1148/149
297.09 (5)	0.72 (7)	d	1444/1146	1005.76 (15)	0.2 (1)	e	1005/gs
299.94 (6)	0.57 (7)		1800/1500	1007.96 (1)	11.6 (1)		1500/492
342.945 (4)	10.2 (1)	c	492/149	1035.5 (5)	0.04 (3)	e	2040/1005
345.6 (1)	0.20 (6)		1444/1098	1066.8 (3)	0.09 (5)		2072/1005
351.48 (7)	0.34 (6)	c	1500/1148	1098.25 (2)	2.5 (1)		1098/gs
353.58 (9)	0.28 (6)		1500/1146	1146.96 (1)	72.0 (4)		1146/gs
384.059 (3)	13.0 (1)	c	876/492	1148.51 (6)	1.6 (1)		1298/149
402.36 (14)	0.10 (5)		1500/1098	1148.9 (···)	0.9 (1)	f	1148/gs
403.3 (···)	0.10 (5)	c	1005/602	1155.8 (2)	0.06 (3)		1757/602
421.32 (7)	0.61 (12)		1427/1005	1184.7 (2)	0.08 (3)		1677/492
438.3 (2)	0.10 (5)		1444/1005	1198.3 (2)	0.08 (2)		1800/602
452.323 (2)	264.5 (7)	c	602/149	1265.2 (2)	0.07 (2)		1757/492
469.7 (1)	0.22 (8)		1346/876	1277.44 (1)	1.71 (7)		1427/149
492.66 (1)	70.2 (3)	c	492/gs	1294.34 (2)	7.0 (1)		1444/149
494.85 (5)	1.1 (1)		1500/1005	1297.98 (16)	0.07 (3)		1298/gs
496.23 (8)	0.5 (1)		1098/602	1308.1 (2)	0.10 (1)		1800/492
544.88 (1)	6.2 (2)		1146/602	1350.91 (4)	0.88 (5)		1500/149
550.4 (1)	0.4 (1)		1427/876	1427.14 (2)	1.53 (5)		1427/gs
567.33 (4)	1.49 (9)		1444/876	1500.62 (3)	1.67 (5)		1500/gs
574.9 (1)	0.45 (7)	c	1427/852	1527.73 (2)	0.83 (4)		1677/149
602.039 (3)	60.9 (3)	c	602/gs	1548.0 (5)	0.013 (7)	e	2040/492
605.55 (2)	1.7 (1)		1098/492	1579.94 (9)	0.12 (1)		2072/492
654.26 (1)	22.2 (2)		1146/492	1650.97 (9)	0.18 (1)		1800/149
696.19 (2)	2.6 (2)		1298/602	[1765.2 (5)]	[0.02 (7)]		···
702.7 (3)	0.11 (8)	e	1800/1098	1800.68 (20)	0.05 (1)		1800/gs
727.00 (2)	6.8 (1)		876/149	1891.1 (3)	0.04 (2)		2040/149
744.4 (3)	0.11 (6)	e	1376/602	1923.6 (2)	0.05 (1)	c	2072/149
805.57 (20)	0.20 (8)		1298/492	[1973.1 (4)]	[0.03 (1)]		···
825.0 (2)	0.4 (1)		1427/602	2040.8 (1)	0.10 (1)		2040/gs
841.99 (2)	2.9 (1)		1444/602	2072.8 (3)	0.09 (2)		2072/gs

[a] Value shown as 109.40(4) means 109.40± 0.04 for example. The uncertainties are one standard deviation.

[b] The intensity values are relative to 1000 for the 149.716-keV transition. To convert to absolute intensities (per 1000 decays) multiply the relative intensity value by 0.681_4. This includes a total conversion coefficient of 0.257 for the 149 keV transition and the assumption of 7% $E2$ character for the 149 keV transition (taken from $^{129}Te \rightarrow {}^{129}I$ data).

[c] The contribution from isomer decay impurity is negligible.

[d] Part of the 297-keV transition is 1148 to 852. $I = 0.1$ as calculated from $^{131}Te^{m}$ decay and measured 999-keV intensity in $^{131}Te^{g}$ decay.

[e] The contribution from the isomer decay impurity has been deleted using intensity ratios in Table I.

[f] 1148.9-keV transition intensity was calculated from known ratios in $^{131}Te^{m}$ decay and the measured 999-keV intensity in $^{131}Te^{g}$ decay.

times (30 sec) were employed to minimize the production of $^{131}Te^{m}$ and ^{131}I. No chemical separations were performed, and counting began ≈5 min after irradiation. The direct γ-ray spectrum was observed, as previously described, with a new source produced every 25 min and the old source moved on to another detector-pulse-height analyzer system. Approximately 19 25-min counts were summed on each of the several systems. No $\gamma\gamma$-coincidence measurements were performed on $^{131}Te^{g}$ decay except those described above, which utilized the equilibrium $^{131}Te^{m+g}$ source.

III. RESULTS

The γ-ray spectrum of an equilibrium source of $^{131}Te^{m+g}$ observed with the 7-cm^3 Ge(Li) detector in the Compton suppression spectrometer is shown in Figs. 1(a)–1(e) with insets from large volume Ge(Li) detectors to clarify certain features and show the high energy portion of the spectrum. A portion of the low-energy spectrum (LEPS) of $^{131}Te^{m+g}$ observed with the 0.6-cm^3 Ge(Li) detector is shown in Figs. 2(a) and 2(b). A total of 260 peaks were observed, including single-escape (SE), double-escape (DE), x-ray escape, x-ray, and sum (SUM) peaks. Fourteen additional transitions were established on the basis of coincidence information, and their intensities were calculated from the coincidence spectra.

The 274 peaks are tabulated in Table I. 190 γ rays were attributed to the decay of 30-h $^{131}Te^m$, although 16 of these were not placed in the decay scheme. A majority of the remaining γ rays were assigned to either $^{131}Te^g$ decay (based on the present work and the work of Macias and Walters[18]) or to ^{131}I decay (based on the work of Meyer, Momyer, and Walters[26]).

In the $^{131}Te^g$ spectra, 80 γ rays were attributed to the decay of 25-min $^{131}Te^g$. These are tabulated in Table II, and 77 of them are placed in a decay scheme for $^{131}Te^g$. In Table I, ground-state decay contributions were determined based on the 997.25-keV transition, and in Table II the isomeric-state decay contributions were determined based on the 773.67-keV and 774.1-keV transitions.

The Ge(Li)-Ge(Li) $\gamma\gamma$-coincidence data were analyzed using the University of Maryland Univac 1108 computer along with computer codes developed at the University of Maryland.[27] Approximately three million coincidence events recorded on magnetic tape were scanned, and coincidence spectra were extracted for 60 peak regions as well as for neighboring regions to account for Compton backgrounds. Energy gates were set on the spectrum obtained with the 65-cm^3 detector, and the spectrum in coincidence with the gated region was retrieved for the 55-cm^3 detector. The results obtained are tabulated in Table I. The coincidence information obtained on $^{131}Te^g$ decay is not shown as it was less complete than, and in agreement with, the work of Macias and Walters.[18]

By observing the growth and decay of daughter ^{131}I in an equilibrium $^{131}Te^{m+g}$ source initially free of ^{131}I, we determined a direct ground state β branch for $^{131}Te^m$ of $(5.2\pm3.0)\%$. This is in good agreement with the previous value of 6%.[15] In $^{131}Te^g$ decay, Davare, Tandon, and Devare[28] were unable to detect any measurable direct β decay to the ground state of ^{131}I.

To determine the 182.2-keV $M4$ IT branch for $^{131}Te^m$ we were unable to directly employ the 182.25-keV transition intensity, as this transition was shown by coincidence measurements to be an unresolved doublet. Therefore we determined a $^{131}Te^m$ β-decay intensity by totaling the intensities of all the transitions assigned to $^{131}Te^m$ decay terminating at the ground state or one of the first three excited states (at 149, 492, and 602 keV). We used the ground-state β-branch value of 5.2% and assumed that there was no direct β decay to the first three excited states. The intensity of the 997.16-keV transition, seen only in $^{131}Te^g$ decay, along with the intensities in Table II, resulted in an intensity value for $^{131}Te^g$ β decay. Comparison of the two β-decay intensities, assuming transient equilibrium, resulted in a value for the IT branch of $(22.2\pm1.6)\%$. This is in fair agreement with the previous value of 18% which was obtained by comparison of the total β spectrum with the K and L conversion lines due to the 182-keV $M4$ IT.[15]

IV. DECAY SCHEMES

The resulting decay scheme for $^{131}Te^m$ is shown in Figs. 3(a)–3(d), and the levels of ^{131}I along with their properties are tabulated in Table III. The notation of Figs. 3(a)–3(d) is the same as in Table III. Energy gates were set on those γ rays depicted in the figures with a dot on their upper end, whereas those γ rays observed in the resulting coincidence spectra are indicated by a dot at their lower end. Dashed transitions are indicated in Table I by parentheses placed around the transition assignment. Dashed levels are placed solely on the basis of sums and differences involving dashed transitions. Energies and intensities of the γ rays are tabulated in Table I, and intensities given on the figures as (205 + 145), for example, indicate γ-ray intensity plus theoretical conversion electron intensity,[29] respectively. In making intensity balances it was assumed that there was no direct β decay from the isomer to the levels at 149, 492, 602, and 1148 keV. The Q_β for $^{131}Te^m$ is 2424 ± 13 keV, calculated based on the masses[30] of ^{130}Te and ^{131}Xe, the Q value for the $^{130}Te(d,p)$ reaction,[31] the measured[32,33] Q_β of ^{131}I, and the isomer at 182 keV. The Q_β value for $^{131}Te^m$ of 2434 ± 6 keV of Wapstra and Gove[30] and the $\log f_0^-$ tables of Gove and Martin[34] were used to calculate $\log ft$ values.

The positions of the first three excited states have been firmly established by $^{131}Te^g$ decay scheme studies[18,23] and by $^{130}Te(^3He,d)$ reaction studies.[6] The two states at 773.67 and 852.21 keV are established by the strong intensities of the two γ rays of these energies, the absence of any coin-

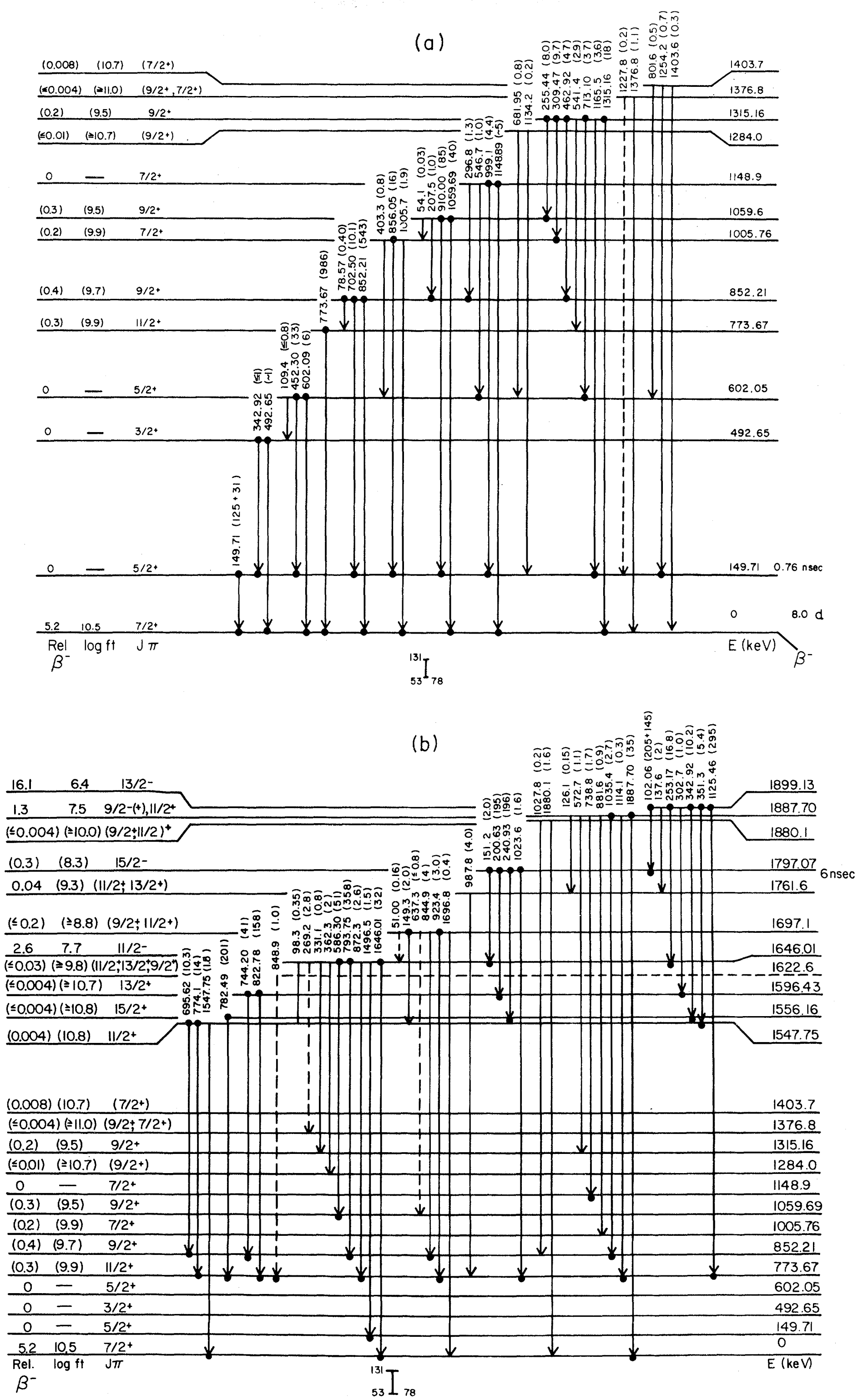

FIG. 3. (a) The partial decay scheme of 30-h $^{131}Te^m$ including β feedings to the levels between ground and 1404 keV. (b) The partial decay scheme of 30-h $^{131}Te^m$ including β feedings to the levels from 1547 and 1899 keV. (c) The partial decay scheme of 30-h $^{131}Te^m$ including β feedings to the levels from 1924 to 2001 keV. (d) The partial decay scheme of 30-h $^{131}Te^m$ including β feeding to the levels from 2010 to 2333 keV.

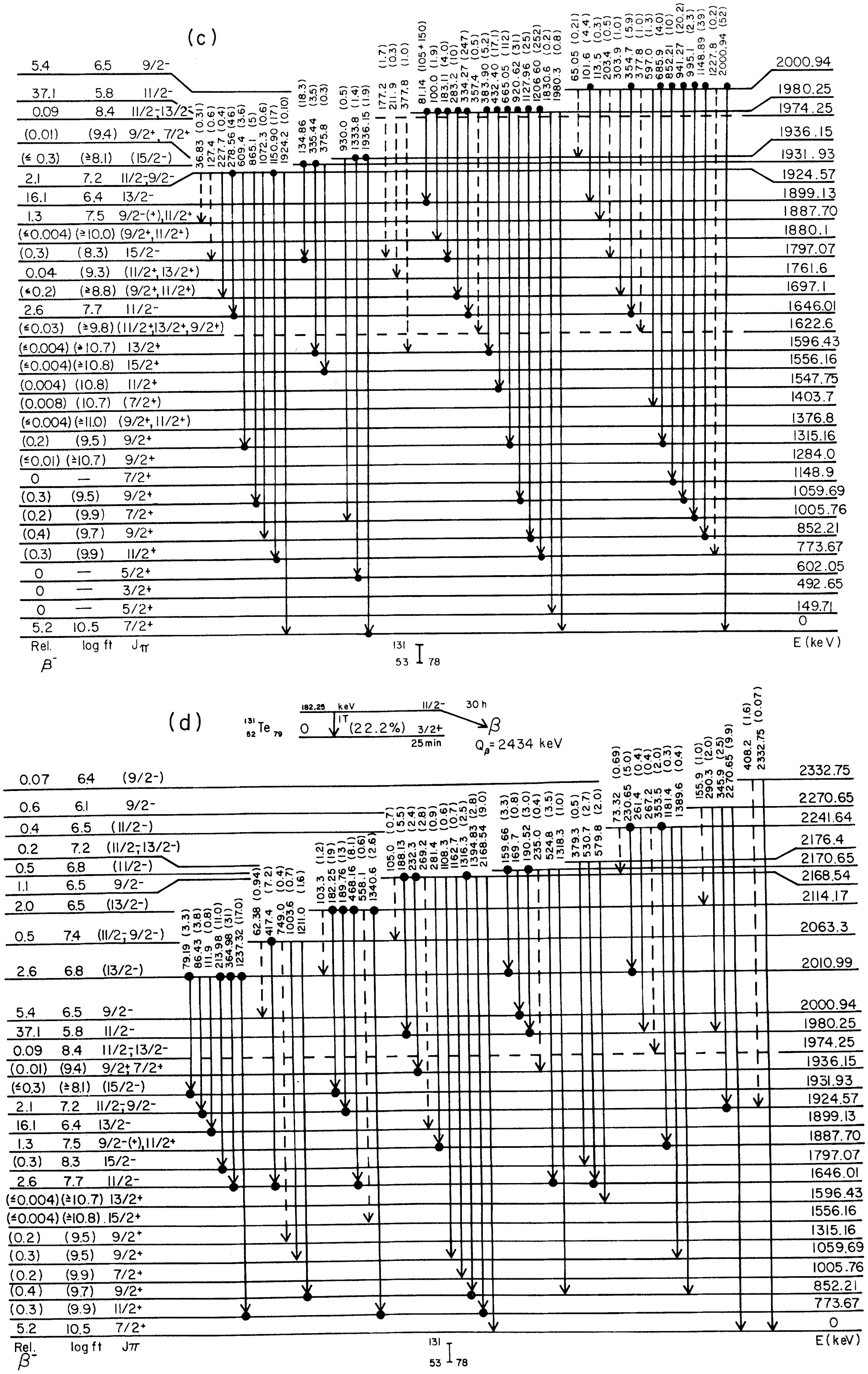

FIG. 3 *(Continued)*

TABLE III. ^{131}I levels observed in the β decay of 30-h $^{131}Te^m$.

Energy (keV)	σ [a] (keV)	Absolute β [b]	σ [a]	log ft	Note	J^π assignment	Energy (keV)	σ [a] (keV)	Absolute β [b]	σ [a]	log ft	Note	J^π assignment
0	···	5.2	3.0	10.5	c	$\frac{7}{2}^+$	1797.07	0.08	0.3	0.7	(8.3)	e	$\frac{15}{2}^-$
149.71	0.01	0	···	···	d	$\frac{5}{2}^+$	1880.1	0.3	−0.02	0.024	(≥10.0)	f	$(\frac{9}{2}^+, \frac{11}{2}^+)$
492.65	0.05	0	···	···	d	$\frac{3}{2}^+$	1887.70	0.07	1.3	0.2	7.5		$\frac{9}{2}^-(+), \frac{11}{2}^+$
602.05	0.06	0	···	···	d	$\frac{5}{2}^+$	1899.13	0.07	16.1	1.2	6.4		$\frac{13}{2}^-$
773.67	0.03	0.3	1.3	(9.9)	e	$\frac{11}{2}^+$	1924.57	0.11	2.1	0.5	7.2		$\frac{11}{2}^-, \frac{9}{2}^-$
852.21	0.03	0.4	1.3	(9.7)	e	$\frac{9}{2}^+$	1931.93	0.10	−0.05	0.3	(≥8.1)	f	$\frac{15}{2}^-$
1005.76	0.07	0.2	0.2	(9.9)	e	$\frac{7}{2}^+$	1936.15	0.09	0.01	0.05	(9.4)	e	$\frac{9}{2}^+, \frac{7}{2}^+$
1059.69	0.04	0.3	0.4	(9.5)	e	$\frac{9}{2}^+$	1974.25	0.20	0.09	0.05	8.4		$\frac{11}{2}^-, \frac{13}{2}^-$
1148.9	0.1	0	···	···	d	$\frac{7}{2}^+$	1980.25	0.10	37.1	1.9	5.8		$\frac{11}{2}^-$
1284.0	0.4	−0.04	0.05	(≥10.7)	f	$(\frac{9}{2}^+)$	2000.94	0.06	5.4	0.6	6.5		$\frac{9}{2}^-$
1315.16	0.08	0.2	0.4	(9.5)	e	$\frac{9}{2}^+$	2010.99	0.08	2.6	0.3	6.8		$\frac{13}{2}^-$
1376.8	0.4	−0.06	0.04	(≥11.0)	g	$(\frac{9}{2}^+, \frac{7}{2}^+)$	2063.3	0.2	0.5	0.08	7.4		$(\frac{11}{2}^-, \frac{9}{2}^-)$
1403.7	0.3	0.008	0.04	(10.7)	e	$\frac{7}{2}^+$	2114.17	0.14	2.0	0.4	6.5		$(\frac{13}{2}^-)$
1547.75	0.10	0.004	0.2	(10.8)	e	$\frac{11}{2}^+$	2168.54	0.09	1.1	0.2	6.5		$\frac{9}{2}^-$
1556.16	0.07	−0.3	0.2	(≥10.8)	g	$\frac{15}{2}^+$	2170.65	0.12	0.5	0.1	6.8		$(\frac{11}{2}^-)$
1596.43	0.07	−0.5	0.3	(≥10.7)	g	$\frac{13}{2}^+$	2176.4	0.2	0.2	0.04	7.2		$(\frac{11}{2}^-, \frac{13}{2}^-)$
1622.6	0.2	−0.02	0.05	(≥9.8)	f	$(\frac{11}{2}^+, \frac{13}{2}^+, \frac{9}{2}^+)$	2241.64	0.13	0.4	0.1	6.5		$(\frac{11}{2}^-)$
1646.01	0.08	2.6	0.9	7.7		$\frac{11}{2}^-$	2270.65	0.09	0.6	0.1	6.1		$\frac{9}{2}^-$
1697.1	0.2	−0.01	0.2	(≥8.8)	f	$(\frac{9}{2}^+, \frac{11}{2}^+)$	2332.75	0.40	0.07	0.04	6.4		$(\frac{9}{2}^-)$
1761.6	0.2	0.04	0.06	(9.3)	e	$(\frac{11}{2}^+, \frac{13}{2}^+)$							

[a] All uncertainties are one standard deviation.
[b] This is the number of β rays to this level per 100 decays of $^{131}Te^m$.
[c] This log ft value is the log f_1t.
[d] A zero β feeding to this level was assumed.
[e] The intensity balance results in a positive β branch, but due to the large uncertainty a zero β branch cannot be ruled out.
[f] The intensity balance results in a negative β branch. The log ft limit is the result of adding the uncertainty value to the calculated value.
[g] The intensity balance results in a negative β branch larger in magnitude than the uncertainty value. The log ft limit comes from assuming a maximum β feeding of 0.1 relative γ-ray units.

cidence between them, as well as a 149.71- by 702.50-keV coincidence.

The level at 1005.76 keV is placed on the basis of a γ ray of this energy and a 149.71- by 856.05-keV coincidence. In addition, these transitions are observed in $^{131}Te^g$ decay, and several weak γ rays observed in $^{131}Te^g$ decay fitted between established low-spin ^{131}I levels and a level at 1005.76 keV. The level at 1059.69 keV is placed on the basis of a γ ray of this energy as well as 149.71- by 910.00- and 852.21- by 207.5-keV coincidences. The level at 1315.16 keV is established on the basis of a γ ray of this energy as well as numerous coincidences including 1059.69- by 255.44-, 1005.7- by 309.47-, 852.21- by 462.92-, and 602.05- by 713.10-keV. The level at 1403.7 keV is established on the basis of a γ ray of this energy and a 149.71- by 1254.2-keV coincidence. The level at 1547.75 keV is established by a γ ray of this energy as well as 773.67- by 774.1- and 852.21- by 695.62-keV coincidences. For all five of these levels the transition to ground does not appear in coincidence with any transitions originating at levels of lower energy.

The levels of 1556.16 and 1596.43 keV are placed by strong 773.67- by 782.49-, and 773.67- by 822.78-keV, coincidences as well as a strong 852.21- by 744.20-keV coincidence. The level at

1646.01 keV is placed by a strong γ ray of this energy as well as 852.21- by 792.75-, 1059.69- by 586.30-, and 149.71- by 1496.5-keV coincidences. In addition, a high-spin level at 1638 ± 10 keV was observed in the (^{3}He, d) reaction work.[6] The level at 1697.1 keV is established on the basis of a γ ray of this energy as well as coincidences indicating feeding to the levels at 773.67 and 852.21 keV. The level at 1797.07 keV is placed on the basis of coincidences between the 200.63-keV γ ray and the 822-773 keV cascade as well as coincidences between the 240.93-keV γ ray and the 782-773 keV cascade. This level has been observed to have a half-life of 6 nsec.[19]

The 1887.70, 1924.57, 1980.25, and 2168.54 keV levels are all placed on the basis of γ rays of these values, coincidences indicating feeding to the level at 773.67 keV, as well as numerous other coincidences indicating feeding to other established levels. The level at 1899.13 keV is established on the basis of numerous coincidences, including 773.67- by 1125.46-, 782.49- by 342.92-, 1646.01- by 253.17-, and 200.63- and 240.93- by 102.06-keV coincidences. The level at 1931.93 keV is placed on the basis of coincidences indicating feeding to the levels at 1596.43 and 1797.07 keV. The level at 1936.15 keV is placed on the basis of a γ ray of this energy as well as 602.05- and 452.30- by 1333.8-keV coincidences.

The level at 2000.94 keV is placed on the basis of a strong γ ray of this energy as well as numerous coincidences, including 1005.7- by 995.1-, 1059.69- by 941.27-, 1315.16- by 685.9-, and 1646.01- by 354.7-keV coincidences. The levels at 2010.99, 2063.3, and 2170.65 keV are all established on the basis of coincidences indicating feeding to the 1646.01 keV level as well as to numerous other previously established levels. The level at 2241.64 keV is placed on the basis of 1887.70- by 353.5- and 1237.32- by 230.65-keV coincidences. The level at 2270.65 keV is placed on the basis of a γ ray of this energy as well as coincidences between the 345.9-keV γ ray and the two strongest transitions out of the level at 1924.57 keV.

The coincidence spectra indicate a strong 1148.89- by 852.21-keV coincidence, and this cascade is a major mode of deexcitation of the level at 2000.94 keV. We have, however, placed levels at both 852.21 and 1148.9 keV. A level at 852.21 keV is established by numerous coincidences between the 852.21-keV γ ray and other γ rays (such as 1127.96-, 1035.4-, 844.9-, and 792.75 keV) which when added to 2000.94 keV result in a value greater than Q_β, and which cannot deexcite a level at 1148.9 keV. The level at 1148.9 keV is established on the basis of the following coincidences: (1) 149.71- by 999.2-keV (=1148.91 keV); (2) 1148.89- by 738.8-keV (=1887.69 keV); (3) 999.2- by 852.21-keV (deexciting 2000.94 keV level); (4) 602.05- by 546.7-keV (=1148.75 keV); and, (5) 999.2- by 738.8-keV. In addition, the ^{131}Te^g decay data indicates the presence of the 999.2-keV transition as well as two doublets (278-280 and 351-353 keV) which may be placed from established low-spin levels to an established level at 1146.95 keV and a new level at 1148.9 keV. The splitting of the 852.21- and 1148.89-keV doublets in ^{131}Te^m decay given in Table I is based on relative intensities from coincidence spectra and on calculating an intensity balance assuming no direct β decay from the isomer to the 1148.9 keV level.

Of the remaining eight levels shown in Figs. 3(a)–3(d) and in Table III, the levels at 1376.8, 1880.1, and 2332.75 keV are established on the basis of γ rays of these energies which were not observed in any coincidence spectra. In addition, each level is the result of one or more sums involving γ rays not assigned to previously established levels. The remaining five levels, 1284.0, 1622.6, 1761.6, 1974.25, and 2176.4 keV, are placed solely on the basis of a number of sums and differences involving γ rays not assigned to previously established levels.

This decay scheme is similar to but much more complex than the most recent decay scheme of ^{131}Te^m.[16] We have eliminated only two previously suggested levels, 1488 and 2231 keV, for which we found no evidence, and we have added 20 new levels to the decay scheme.

The resulting decay scheme for 25-min ^{131}Te^g is shown in Figs. 4(a) and 4(b), and the levels of ^{131}I along with their properties are tabulated in Table IV. The notation is the same as is used in Figs. 3(a)–3(d) and in Table III. The energies and intensities of the γ rays are tabulated in Table II. The Q_β for ^{131}Te^g is 2242 ± 13 keV, calculated as described above. (The value of 2252 ± 6 keV of Wapstra and Gove[30] was used in logft calculations.) The β-branch values are based on a zero direct β feeding from ^{131}Te^g to the ^{131}I ground state,[28] and the logft values were calculated using the logf_0^- tables of Gove and Martin.[34]

For the ground state decay of ^{131}Te, most of the levels were established by the decay scheme work of Macias and Walters[18] and the (^{3}He, d) reaction work of Auble, Ball, and Fulmer.[6] We have observed a number of new weak γ transitions and we have placed six new levels. Three of these 852.21, 1005.76, and 1148.9 keV, are also observed in ^{131}Te^m decay. The level at 1757.9 keV is placed on the basis of two γ rays which may feed the levels at 492.66 and 149.716 keV. The levels at 2040.8 and 2072.6 keV are placed on the basis of γ rays of these energies as well as three addition-

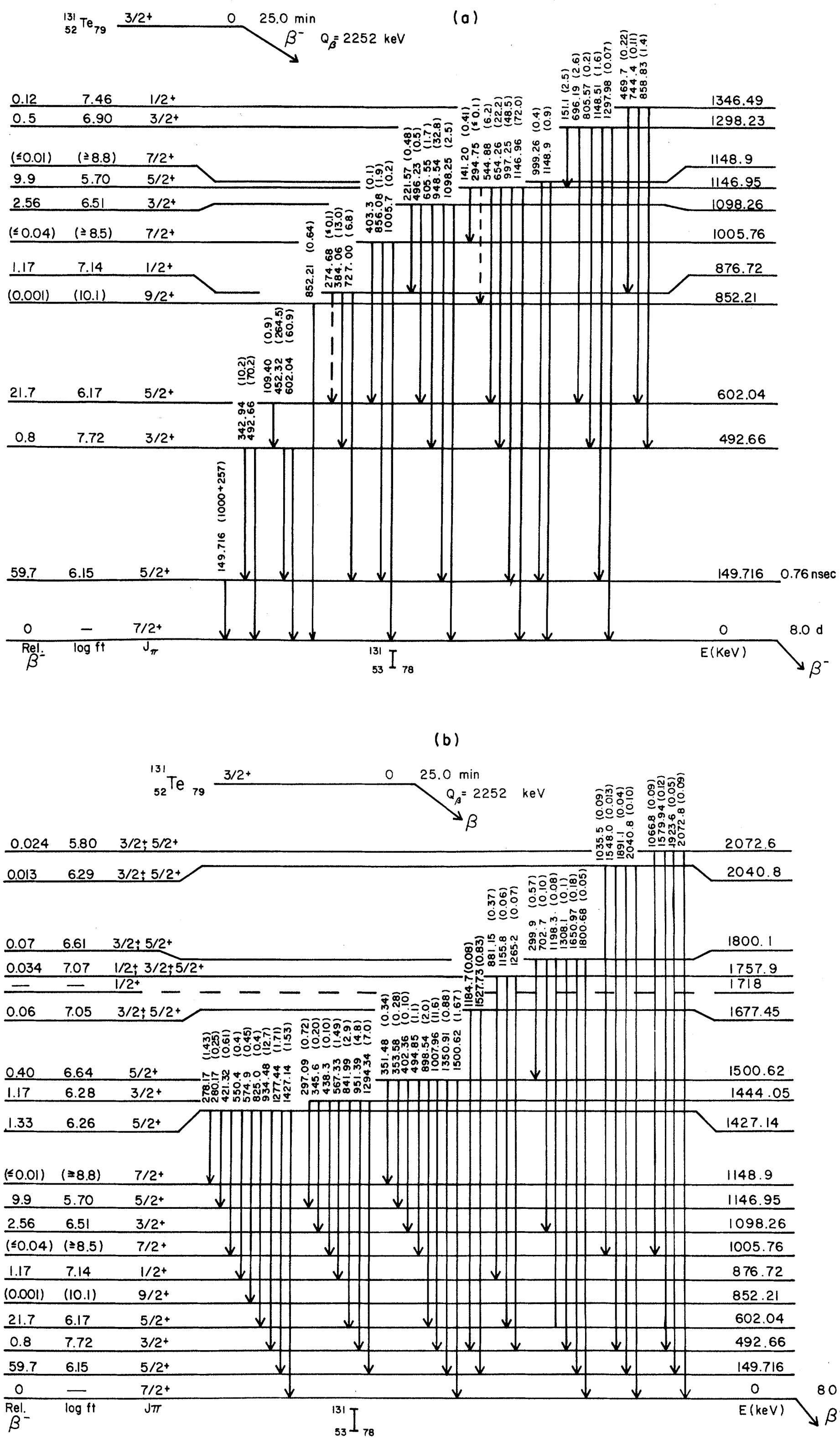

FIG. 4. (a) The partial decay scheme of 25-min $^{131}Te^{g}$ including β feedings to the levels between ground and 1347 keV. (b) The partial decay scheme of 25-min $^{131}Te^{g}$ including β feedings to the levels from 1427 to 2073 keV.

TABLE IV. ^{131}I levels observed in the β decay of 25-min $^{131}Te^{g}$.

Energy (keV)	σ [a]	Absolute β [b]	σ [a]	log*ft*	Note	J^{π} assignment
0	...	0	...	...	c	$\frac{7}{2}^+$
149.716	0.005	59.7	0.6	6.15		$\frac{5}{2}^+$
492.66	0.01	0.8	0.1	7.72		$\frac{3}{2}^+$
602.04	0.01	21.7	0.2	6.17		$\frac{5}{2}^+$
852.21	0.06	0.001	0.020	(10.1)	d	$\frac{9}{2}^+$
876.72	0.02	1.17	0.05	7.14		$\frac{1}{2}^+$
1005.76	0.04	−0.01	0.05	(≥8.5)	e	$\frac{7}{2}^+$
1098.26	0.02	2.56	0.04	6.51		$\frac{3}{2}^+$
1146.95	0.02	9.9	0.2	5.70		$\frac{5}{2}^+$
1148.9	0.1	−0.02	0.03	(≥8.8)	e	$\frac{7}{2}^+$
1298.23	0.03	0.5	0.1	6.90		$\frac{3}{2}^+$
1346.49	0.06	0.12	0.02	7.46		$\frac{1}{2}^+$
1427.14	0.03	1.33	0.07	6.26		$\frac{5}{2}^+$
1444.05	0.03	1.17	0.06	6.28		$\frac{3}{2}^+$
1500.62	0.03	0.40	0.04	6.64		$\frac{5}{2}^+$
1677.45	0.05	0.06	0.01	7.05		$\frac{3}{2}^+, \frac{5}{2}^+$
1718	10	...	...	...	f	$\frac{1}{2}^+$
1757.9	0.1	0.034	0.007	7.07		$\frac{1}{2}^+, \frac{3}{2}^+, \frac{5}{2}^+$
1800.7	0.1	0.07	0.02	6.61		$\frac{3}{2}^+, \frac{5}{2}^+$
2040.8	0.1	0.013	0.005	6.29		$\frac{3}{2}^+, \frac{5}{2}^+$
2072.6	0.1	0.024	0.006	5.80		$\frac{3}{2}^+, \frac{5}{2}^+$

[a] All uncertainties are one standard deviation.
[b] Number of β rays to this level per 100 decays of $^{131}Te^{g}$.
[c] Zero β feeding to this level was assumed.
[d] The intensity balance gives a positive β branch but due to the large uncertainty a zero β branch cannot be ruled out.
[e] The intensity balance gives a negative β branch. The log*ft* limit is the result of adding the uncertainty value to the calculated value.
[f] This level was seen in (^{3}He, *d*) reaction studies, however there was no definite evidence for this level in this study of $^{131}Te^{g}$ decay.

al transitions apiece. In addition, the (^{3}He, *d*) reaction work placed a level at 2040 ± 15 keV.[6] The newly observed weak γ rays were placed on the basis of precise sums and differences.

We have reassigned the 1579.94-keV transition which was used by Macias and Walters to place a level at 1729 keV.[18] Their observation of a 149- by 1579-keV coincidence was marginal, and we were unable to detect this coincidence. A search for any other possible transitions deexciting a level of this energy proved unsuccessful. The (^{3}He, *d*) reaction work placed a level at 1718 ± 10 keV with an assignment of $\frac{1}{2}^+$ and a relatively large spectroscopic factor (0.31). The most probable transitions from such a level would be to the 149 keV level (1569 ± 10 keV) or the 493 keV level (1226 ± 10 keV). A close examination of our singles spectra resulted in lower limits for such transitions of $I_\gamma(1569) \leq 0.02$ (in two spectra) and $I_\gamma(1226) \leq 0.01$ (in all spectra).

V. SPIN AND PARITY ASSIGNMENTS

The spin and parity assignments of the ^{131}I levels seen in the decay of 25-min $\frac{3}{2}^+$ $^{131}Te^{g}$ are shown in Figs. 4(a) and 4(b) and Table IV. These assignments are essentially taken from the work of Macias and Walters.[18] The assignments of the three newly observed levels seen also in the $^{131}Te^{m}$ decay will be discussed in the context of the decay scheme of the $\frac{11}{2}^-$ isomer. The level at 1757.9 keV is assigned as $\frac{1}{2}^+$, $\frac{3}{2}^+$, and $\frac{5}{2}^+$ based on a log*ft* value of 7.07, indicative of allowed β decay. With log*ft* values <6.3 and direct transitions to the $\frac{7}{2}^+$ ground state, the levels at 2040.8 and 2072.6 keV are assigned as $\frac{3}{2}^+$ and $\frac{5}{2}^+$. The levels at 1146.95 and 1427.14 keV ($\frac{3}{2}^+$ and $\frac{5}{2}^+$ in Macias and Walters) are assigned as $\frac{5}{2}^+$ based on transitions to the $\frac{9}{2}^+$ state at 852.21 keV. The remaining $\frac{3}{2}^+$ and $\frac{5}{2}^+$ states have been given one or the other assignment based on branching ratios to $\frac{1}{2}^+$ and $\frac{7}{2}^+$ states and on some systematic considerations. These levels may well have either assignment however.

The spin and parity assignments of the levels of ^{131}I observed in the β decay of 30-h $\frac{11}{2}^-$ $^{131}Te^{m}$ are shown in Figs. 3(a)–3(d) and in Table III. These assignments are based on log*ft* values for the β decay of the $\frac{11}{2}^-$ isomer, the γ-ray deexcitation patterns between levels, and the earlier conversion electron measurements.[15,17] The assignments for the ground state and the states at 149.71, 492.65, and 602.05 keV are taken from the $^{131}Te^{g}$ decay scheme work.[18]

All of the levels from 773.67 to 1403.7 keV are limited to spin and parity values of $\frac{7}{2}^+$, $\frac{9}{2}^+$, and $\frac{11}{2}^+$ by their prompt γ transitions to the $\frac{7}{2}^+$ ground state, the lack of observed direct β feeding in the decay of 25-min $\frac{3}{2}^+$ $^{131}Te^{g}$, and their γ feeding from numerous higher-lying levels with spin values of $\frac{9}{2}$, $\frac{11}{2}$, and $\frac{13}{2}$. The even parity assignments are consistent with the log*ft* values ranging from 9.5 to ≥11.0, reflecting first-forbidden β decay. The levels at 852.21, 1059.69, 1315.16, and 1376.8 keV are assigned as $\frac{9}{2}^+$ based on their prompt decay to the $\frac{5}{2}^+$ state at 149.71 keV and their γ feeding from the $\frac{11}{2}^-$ state at 1646.01 keV (although the 1376.8 keV level may be $\frac{7}{2}^+$ as the 269.2-keV γ

transition is dashed in and is placed twice). The state at 1284.0 keV is assigned as $\frac{9}{2}^+$ based on decay to $\frac{5}{2}^+$ states and feeding from the $\frac{11}{2}^-$ level at 1646.01 keV. The states at 1005.76, 1148.9, and 1403.7 keV are assigned as $\frac{7}{2}^+$ based on γ feeding from $\frac{9}{2}^-$ states, the lack of feeding from $\frac{11}{2}^-$ states, and their pattern of strong decay branches to the $\frac{5}{2}^+$ 602.05 keV level. In addition, the 1005.76 and 1148.9 keV levels are fed by several $\frac{3}{2}^+$ and $\frac{5}{2}^+$ levels in $^{131}Te^g$ decay. The level at 773.67 keV is assigned as $\frac{11}{2}^+$ based on the absence of any transitions from or to any $\frac{3}{2}^+$ or $\frac{5}{2}^+$ levels, and on the systematic presence of an $\frac{11}{2}^+$ level in ^{127}I and ^{129}I firmly established by (n, n', γ), $\gamma\gamma'$, and Coulomb excitation studies.[35,36]

The state at 1646.01 keV was observed in the (^{3}He, d) work of Auble *et al.*[6] They reported an l value of 5 and a spectroscopic factor (C^2S_J) of 0.70. They assigned the state as $\frac{11}{2}^-$ and interpreted it as being predominantly $h_{11/2}$ single particle in character. The logft value of 7.7 is somewhat high for an allowed β transition but is considerably lower than the values for the first forbidden β transitions. Allowed β transitions with logft values as high as 9.7 have been found in the decay[1,2] of 9.4-h $^{127}Te^g$.

The ten states 1899.13, 1980.25, 2000.94, 2010.99, 2114.17, 2168.54, 2170.65, 2241.64, 2270.65, and 2332.75 keV, all have logft values $\leqslant 6.8$ and are assigned spin and parity values of $\frac{9}{2}^-$, $\frac{11}{2}^-$, or $\frac{13}{2}^-$ consistent with allowed β decay from $\frac{11}{2}^-$ $^{131}Te^m$. The four states with large γ branches to the $\frac{7}{2}^+$ ground state, 2000.94, 2168.54, 2270.65, and 2332.75 keV, are assigned as $\frac{9}{2}^-$. The states at 1980.25, 2170.65, and 2241.64 keV lack or have very weak branches to the ground state, lack branches to any of the $\frac{7}{2}^+$ excited states, and have strong branches to various of the low-energy $\frac{9}{2}^+$ states. They are assigned spin and parity of $\frac{11}{2}^-$. The remaining three states, 1899.13, 2010.99, and 2114.17 keV, are assigned spin and parity of $\frac{13}{2}^-$ on the basis of a lack of observed branches to any $\frac{7}{2}^+$ or $\frac{9}{2}^+$ states and the presence of strong branches to the 773.67 keV $\frac{11}{2}^+$ state. These assignments are all consistent with the conversion electron measurements[15,17] which indicate the 81.14-keV transition (1980 to 1646 keV) to be $M1+E2$.

The conversion electron measurements have shown the 102.06-keV transition (1899 to 1797 keV) to be pure $M1$ and the 200.63-keV (1797 to 1596 keV) and 240.93-keV (1797 to 1556 keV) transitions to be $E1$. Thus the level at 1797.07 keV must be of odd parity while the levels at 1556.16 and 1596.43 keV must be of even parity. The assignment of $\frac{13}{2}^-$ to the 1899.13 keV level restricts the 1797.07 keV level to spin values of $\frac{11}{2}$, $\frac{13}{2}$, and $\frac{15}{2}$. The half-life of the 1797.07 keV level has been measured to be 6 nsec.[19] The upper limit for the intensity of a 1797.07-keV transition to ground was determined to be $\leqslant 0.1$ intensity units. This results in a partial half-life for the 1797.07-keV transition of $\geqslant 25$ μsec. The theoretical single-particle half-lives (with statistical factor omitted)[37] for an $M2$ ($\frac{11}{2}^-$ to $\frac{7}{2}^+$) or $E3$ ($\frac{13}{2}^-$ to $\frac{7}{2}^+$) transition of this energy are 1.2×10^{-11} sec and 5.9×10^{-9} sec, respectively. Thus the hindrances would be $\geqslant 2\times10^6$ and $\geqslant 4200$, respectively. The partial half-life of the 1023.6-keV transition to the $\frac{11}{2}^+$ level at 773.67 keV is 1.5 μsec. The theoretical single-particle half-lives[37] for an $E1$ ($\frac{11}{2}^-$ to $\frac{11}{2}^+$ or $\frac{13}{2}^-$ to $\frac{11}{2}^+$), $M2$ ($\frac{15}{2}^-$ to $\frac{11}{2}^+$), or $E3$ ($\frac{15}{2}^-$ to $\frac{11}{2}^+$) transition of this energy are 1.6×10^{-16} sec, 2.0×10^{-10} sec, and 3.1×10^{-7} sec, respectively. The $E1$ hindrance would be $\approx 10^{10}$, whereas the $M2$ hindrance would be ≈ 7500, and the $E3$ hindrance would be ≈ 5. We therefore propose a spin and parity assignment of $\frac{15}{2}^-$ for the 1797.07 keV isomeric level as being most consistent with known trends of observed and theoretical γ-transition rates.[38,39] We take the logft value of 8.3 as a lower limit due to the large uncertainty involved in the intensity balance for this level.

The assignment of the 6-nsec isomer as $\frac{15}{2}^-$, along with the conversion measurements on the 200.63 and 240.93-keV transitions, limits the levels at 1556.16 and 1596.43 keV to spin and parity values of $\frac{13}{2}^+$, $\frac{15}{2}^+$, or $\frac{17}{2}^+$. The 1596.43 keV level is assigned as $\frac{13}{2}^+$ on the basis of prompt γ-ray transitions to the $\frac{9}{2}^+$ state at 852.21 keV and the $\frac{11}{2}^+$ state at 773.67 keV and the lack of any observed branches to any levels of lower spin. The 1556.16 keV state decays solely via an intense prompt γ transition to the $\frac{11}{2}^+$ state at 773.67 keV and is fed from odd parity levels of spin $\geqslant \frac{13}{2}$. Thus, we propose a spin and parity assignment of $\frac{15}{2}^+$ for this level.

The level at 1547.75 keV is assigned as $\frac{11}{2}^+$ on the basis of transitions to $\frac{7}{2}^+$, $\frac{9}{2}^+$, and $\frac{11}{2}^+$ levels, feeding from $\frac{11}{2}^-$ and $\frac{13}{2}^-$ levels, and a logft value of 10.8. We favor assignment of $\frac{11}{2}^+$ to the levels at 1622.6 and 1761.6 keV on the basis of logft values and transitions to only the $\frac{11}{2}^+$ level at 773.67 keV, although $\frac{9}{2}^+$ and $\frac{13}{2}^+$ assignments are not ruled out. The level at 1697.1 keV feeds levels with assignments $\frac{11}{2}^+$, $\frac{11}{2}^-$, $\frac{7}{2}^+$, and $\frac{9}{2}^+$ and is fed from $\frac{9}{2}^-$ and $\frac{11}{2}^-$ levels. We favor an assignment of $\frac{9}{2}^+$ but cannot rule out $\frac{11}{2}^+$. With a logft value of $\geqslant 10.0$ and transitions to $\frac{7}{2}^+$ and $\frac{9}{2}^+$ and feeding from an $\frac{11}{2}^-$ level, we assign a value of $\frac{9}{2}^+$ or $\frac{11}{2}^+$ to the 1880.1 keV level. The logft value of 7.5 and strong transitions to $\frac{7}{2}^+$, $\frac{9}{2}^+$, and $\frac{11}{2}^+$ levels as well as feeding from $\frac{9}{2}^-$ and $\frac{11}{2}^-$ levels lead us to prefer an assignment of $\frac{9}{2}^-$ for the 1887.70 keV level.

However, we cannot rule out $\frac{9}{2}^+$ or $\frac{11}{2}^+$, although these two assignments are unlikely in view of the log*ft* values for first forbidden β transitions already observed in $^{131}Te^m$ decay.

The log*ft* value of 9.4 and strong transitions to $\frac{5}{2}^+$ and $\frac{7}{2}^+$ states as well as feeding from a $\frac{9}{2}^-$ state lead us to assign the 1936.15 keV state as $\frac{9}{2}^+$ or $\frac{7}{2}^+$. The state at 1931.93 keV is assigned as $\frac{15}{2}^-$ on the basis of observing transitions only to levels with spin and parity $\frac{15}{2}^-$, $\frac{15}{2}^+$, or $\frac{13}{2}^+$ and feeding only from $\frac{13}{2}^-$ levels. The states at 1924.57 and 2063.3 keV are assigned as $\frac{11}{2}^-$ or $\frac{9}{2}^-$ on the basis of log*ft* values suggesting allowed β decay and γ transitions only to levels with spin and parity values of $\frac{11}{2}^-$, $\frac{11}{2}^+$, or $\frac{9}{2}^+$. The levels at 1974.25 and 2176.4 keV feed $\frac{15}{2}^-$ and $\frac{13}{2}^+$ levels and are fed reasonably strongly in β decay. We therefore assigned these levels spin and parity values of $\frac{11}{2}^-$ or $\frac{13}{2}^-$.

VI. DISCUSSION

Our study of the decay of the $\frac{11}{2}^-$ isomer of ^{131}Te has offered the opportunity to examine the charac-

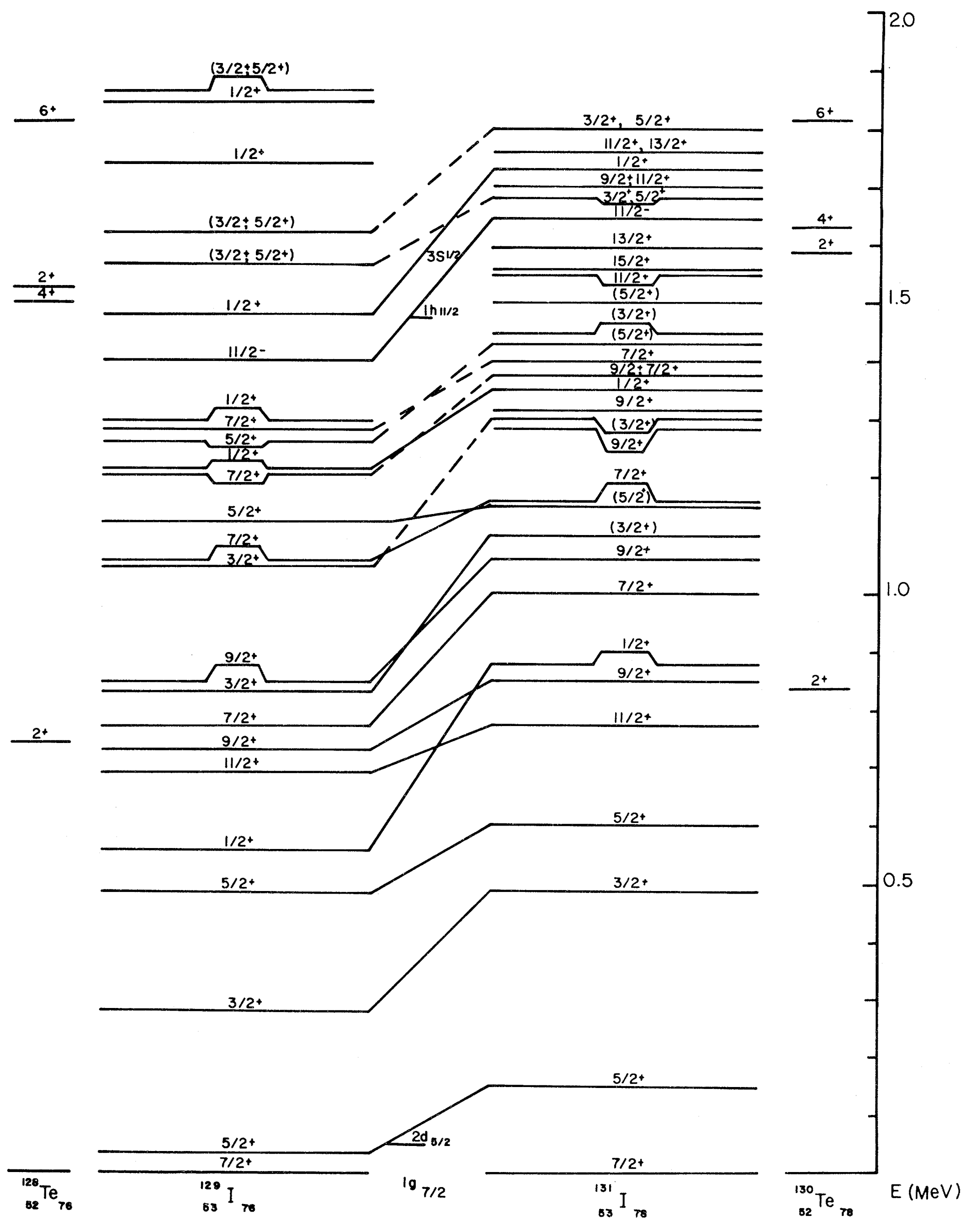

FIG. 5. The levels of ^{131}I (this work and Ref. 6) compared to the levels of ^{129}I (Refs. 3, 4). Also shown are the even-even Te core states (Refs. 40–45).

TABLE V. Possible low-lying states in ^{130}Te and the energies (in keV) of those states observed in ^{130}Te.

Type of excitation of particle configuration	J^π of resultant state								
One phonon			2^+(839)						
Two phonon	0^+		2^+(1588)		4^+(1632)				
Octupole				3^-(2732)					
$\nu(1h_{11/2})^2$	0^+		2^+		4^+		6^+	8^+	10^+
$\nu(2d_{3/2})^2$	0^+		2^+						
$\nu(3s_{1/2})^2$	0^+								
$\nu(1h_{11/2},\ 2d_{3/2})$					4^-	5^-	6^- (2100)	7^-(2147)	
$\nu(1h_{11/2},\ 3s_{1/2})$						5^-	6^-		
$\nu(2d_{3/2},\ 3s_{1/2})$		1^+	2^+ (1880)						
$\pi(1g_{7/2},\ 2d_{5/2})$		1^+	2^+	3^+	4^+	5^+	6^+ (1815)		
$\pi(1g_{7/2})^2$	0^+		2^+		4^+		6^+		
$\pi(2d_{5/2})^2$	0^+		2^+		4^+				

ter of a large number of states of ^{131}I. Added to the results of the $\frac{3}{2}^+$ $^{131}Te^g$ decay study and the earlier ^{130}Te(^{3}He, d) reaction work[6] we now have a total of 55 excited states placed in ^{131}I below 2.4 MeV. These states may be separated into several major categories, single quasiparticle proton states, single proton plus Te core excitation states (largely even parity), proton three quasiparticle states, three proton quasiparticle plus Sn core excitation states, and three quasiparticle states constructed from one-proton–two-neutron configurations (largely odd parity).

In Fig. 5 we compare the levels of ^{131}I below ≈1.9 MeV with the levels of ^{129}I observed in the decays of 69-min $\frac{3}{2}^+$ $^{129}Te^g$,[3] and 34.1-day $\frac{11}{2}^-$ $^{129}Te^m$,[4] and in the ^{128}Te(^{3}He, d) reaction.[6] Also shown are the low-lying even parity excited states observed in the even-even cores, ^{128}Te and ^{130}Te.[40-45] The notation of the $1g_{7/2}$, $2d_{5/2}$, $1h_{11/2}$, and $3s_{1/2}$ single quasiparticle levels is made for the levels of the appropriate spin and parity having the largest spectroscopic factors in the (^{3}He, d) reaction. The $2d_{3/2}$ state in both ^{131}I and ^{129}I remains uncertain. It may be noted that qualitatively the two level structures are quite similar. The ^{129}I level structure is lacking in observed high-spin ($\geq\frac{13}{2}$) states and in odd parity states, but this is understandable as the Q_β of $^{129}Te^m$ is only 1602 keV.[30] The single quasiparticle levels are seen to rise in energy from ^{129}I to ^{131}I. This continues a similar behavior seen when going from ^{127}I[1,2,6,35] to ^{129}I. There is also a general increase in energy of all of the positive parity levels from ^{129}I to ^{131}I which parallels the increase in energy of the core excitations (2^+ one-phonon and 4^+, 2^+ two-phonon states) from ^{128}Te to ^{130}Te. Thus the positive parity states behave as if they result from the coupling of the core excitations to the single quasiparticle $1g_{7/2}$ and $2d_{5/2}$ states.

The general features of the level structure of ^{131}I may be understood in terms of the single quasiparticle proton states coupling to core excitations or to two quasiparticle states in the ^{130}Te core. In Table V we show the spins, parities, and configurations expected in the low-lying ^{130}Te level structure, along with the energies of those states which have been observed. Not all of these states have been observed and identified in ^{130}Te; however, an examination of the structure of the even-even Sn isotopes for $A=122$, 124, and 126 and the even-even Te isotopes for $A=122$, 124, 126, 128, and 130[44-48] indicates that most of these states are present. The coupling of these core states to the single quasiparticle proton states results in a large number of states of even parity ranging from spins of $\frac{1}{2}$ to $\frac{27}{2}$ and odd parity ranging from $\frac{1}{2}$ to $\frac{21}{2}$.

In ^{130}Te, the one-phonon and two-phonon excitations both lie lower than the lowest observed two quasiparticle level, a 6^+ state at 1815 keV (see Figs. 5 and 6). Thus, although one expects a certain amount of configuration mixing at higher energies, it appears probable that the phonon states in ^{131}I should be identifiable, particularly the one-phonon excitations. In Table VI we have shown the distribution of states resulting from coupling the Te one- and two-phonon excitations to the $1g_{7/2}$ and $2d_{3/2}$ single quasiparticle states and from a $(\pi 1g_{7/2})^3$ configuration and its coupling to the 2^+ one-phonon state in ^{128}Sn, along with a count of the number of states of each spin and parity observed in ^{131}I below 2.0 MeV. This is illustrated schematically in Fig. 6, which shows the observed even parity states in ^{130}Te,[42, 43, 45] the result of a zeroth-order coupling of these states with the $\frac{7}{2}^+$ and $\frac{5}{2}^+$ states (ground and 149.71 keV) in ^{131}I, the result of a zeroth-order coupling of the observed $(\pi 1g_{7/2})^3\ \frac{5}{2}^+$ state (602.05 keV) with the ^{128}Sn one-phonon state, and the observed levels in ^{131}I below 2.0 MeV. The connections between states are made on the basis of possible spin values and on the deexcitation branchings to the $\frac{7}{2}^+$ and $\frac{5}{2}^+$ single quasiparticle states. It may be observed that all ten states resulting from the coupling of the two single quasiparticle states to the 2^+ one-phonon ^{130}Te core state have been identified, and that the second phonon excitation can account for the re-

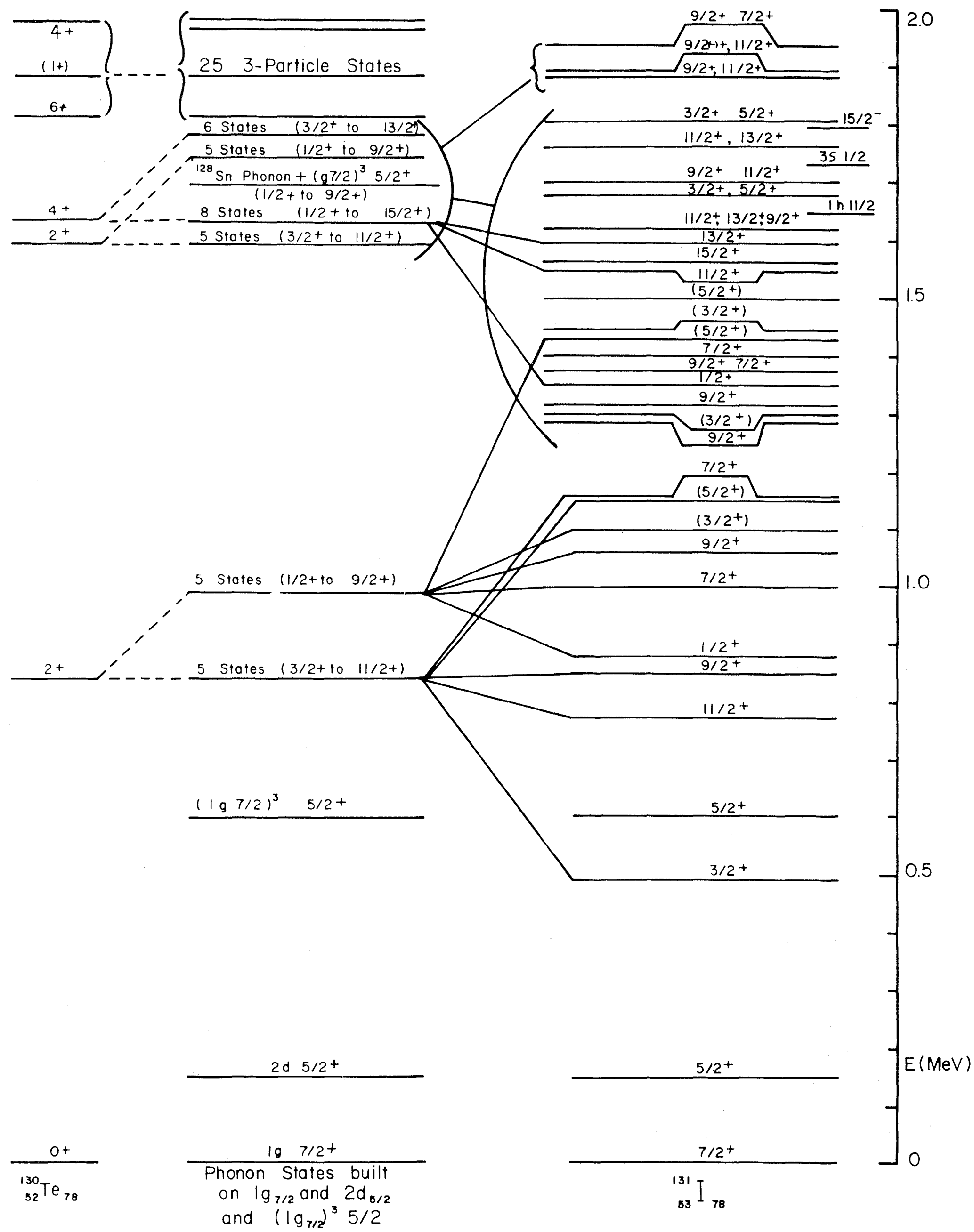

FIG. 6. The even parity levels of ^{131}I (this work and Ref. 6). On the left are the even parity ^{130}Te core states (Refs. 42, 43, 45), and in the center are the states arising from a zeroth-order coupling of the Te core to the $1g_{7/2}$ and $2d_{5/2}$ states in ^{131}I, and of the Sn core to the $(1g_{7/2})^3\frac{5}{2}+$ state in ^{131}I.

TABLE VI. Distribution of even parity states of ^{131}I below $\sim$2 MeV predicted by zeroth-order coupling of the one-phonon and two-phonon excitations in ^{130}Te with the $1g_{7/2}$ and $2d_{5/2}$ shell-model orbitals, and by the $(1g_{7/2})^3$ configuration and the coupling of the configuration, $(1g_{7/2})^3\,\frac{5}{2}^+$ to the one-phonon excitation in ^{128}Sn. The $3s_{1/2}$ and $2d_{3/2}$ shell-model orbitals are also included. The number of observed levels of each J^π is also shown (this work and Ref. 6).

J^π	Theor. one phonon	Obs. one phonon	Theor. $(1g_{7/2})^3$	Obs. $(1g_{7/2})^3$	Theor. $(1g_{7/2})^3\,\frac{5}{2}^+$ + Sn phonon	Theor. two phonon	Obs. high energy even parity states
$\frac{1}{2}^+$	1	1	···	···	1	3 [a]	2; 1 [c] ($\frac{1}{2}^+$–$\frac{5}{2}^+$)
$\frac{3}{2}^+$	2	2	1	0	1	4 [b]	2; 3 [c] ($\frac{3}{2}^+$–$\frac{5}{2}^+$)
$\frac{5}{2}^+$	2	2	1	1	1	5	1
$\frac{7}{2}^+$	2	2	1	0	1	5	1; 2 [c] ($\frac{7}{2}^+$–$\frac{9}{2}^+$)
$\frac{9}{2}^+$	2	2	1	0	1	4	2; 3 [c] ($\frac{9}{2}^+$–$\frac{11}{2}^+$); 1 [c] ($\frac{9}{2}^+$–$\frac{13}{2}^+$)
$\frac{11}{2}^+$	1	1	1	0	···	3	1; 1 [c] ($\frac{11}{2}^+$–$\frac{13}{2}^+$)
$\frac{13}{2}^+$	···	···	···	···	···	2	1
$\frac{15}{2}^+$	···	···	1	0	···	1	1

[a] Includes the $3s_{1/2}$ shell-model orbital.
[b] Includes the $2d_{3/2}$ shell-model orbital.
[c] Indicates states which are assigned more than one possible J^π value.

maining observed even parity states. Most of the "missing" states are $\frac{7}{2}^+$, which are very difficult to observe in the β decay of $\frac{3}{2}^+$ or $\frac{11}{2}^-$ isomers or in the (^{3}He, d) reaction.

In Fig. 7 we show a comparison of the experimental even-parity levels of ^{131}I with the detailed calculations of Rustgi, Lucas, and Mukherjee[7] (proton plus ^{130}Te core), Kisslinger and Sorenson[49] (quasiparticle plus Te phonon), and Almar, Civitarese, and Krmpotic[11] (three-proton cluster plus Sn core phonon). The agreement between theory and experiment is reasonable; however, the positions of some states are not identified in the theoretical calculations, namely the $\frac{13}{2}^+$ and $\frac{15}{2}^+$ states and some of the $\frac{9}{2}^+$ or $\frac{11}{2}^+$ states. Some of these states were not calculated as the core states used included only first and second phonon states and the models used are not very realistic at high excitation energies.[7,49] The three-proton cluster plus Sn core model clearly gives the best explanation of the observed density of even parity states, and presumably extensions of this model to higher spin states and higher excitation energies would improve the fit to the experimental levels.

These three approaches, however, have not been applied to try to understand the configurations of the odd parity levels observed in ^{131}I. Of these levels, the $\frac{15}{2}^-$ 6-nsec isomer at 1797.07 keV is of particular interest. A $\frac{15}{2}^-$ isomer has been reported in ^{127}Sb (one α particle removed from ^{131}I) by Apt and Walters.[2,50,51] That isomer has an 11-μsec half-life and decays by two transitions of nearly equal intensity (805.9 and 824.7 keV) to levels with spin and parity values of $\frac{9}{2}^+$ and $\frac{11}{2}^+$. The partial half-life of the 1035.4-keV transition in ^{131}I ($\frac{15}{2}^-$ to $\frac{11}{2}^+$) is 1.5 μsec. The equivalent transition in ^{127}Sb, corrected for energy differences, has a partial half-life of $\approx$5.0–8.0 μsec (pure $M2$) or of $\approx$3.0–6.0 μsec (pure $E3$). As with ^{130}Te, the ^{126}Sn core has a 5^- and a 7^- excited state near 2 MeV in excitation energy.[52] It seems highly likely then that these two $\frac{15}{2}^-$ isomers are very similar in configuration.

Apt and Walters[2,50,51] have proposed that the $\frac{15}{2}^-$ isomer in ^{127}Sb is the result of coupling the $1g_{7/2}$ single-proton state with the 5^- state in ^{126}Sn, and they have proposed that the principal configuration is $[\pi 1g_{7/2}, (\nu_1 1h_{11/2}, \nu_2 2d_{3/2})5^-]\frac{15}{2}^-$. Some light is shed on the interpretation of the $\frac{15}{2}^-$ isomer in ^{131}I by the work of Tandon and Devare.[20] They measured the g factor of this isomeric level to be -0.16 ± 0.05. In Table VII we show the result of calculating the g factor for each of the eleven possible $\pi\nu_1\nu_2$ configurations resulting in a $\frac{15}{2}^-$ state. It is seen that only two configurations,

$$[\pi 1g_{7/2}, (\nu_1 1h_{11/2}, \nu_2 2d_{3/2})4^-]\tfrac{15}{2}^-$$

and

$$[\pi 1g_{7/2}, (\nu_1 1h_{11/2}, \nu_2 2d_{3/2})5^-]\tfrac{15}{2}^-,$$

result in a calculated g factor within two standard deviations of the measured value. We favor the second configuration, as the 4^- state has not been observed and identified in ^{130}Te.

The deexcitation of the $\frac{15}{2}^-$ isomer proceeds via transitions to the $\frac{11}{2}^-$ single-proton state at 1646.01 keV, to the two-phonon coupled to $1g_{7/2}$ states at 1596.43 and 1556.13 keV ($\frac{13}{2}^+$ and $\frac{15}{2}^+$), and to the one-phonon coupled to $1g_{7/2}$ state at 773.67 keV ($\frac{11}{2}^+$). The first of these transitions is a 151.2-keV pure $E2$ transition with a partial half-life of ~1.2 μsec. The theoretical single-particle half-life[37] is 84 nsec. The $E2$ hindrance of ~14 is indicative of the great difference in configuration between the two states. The transition very likely proceeds as a result of a small amount of configuration mixing of $\pi\nu_1\nu_2$ character into the 1646.01 keV state and one-phonon plus $1h_{11/2}$ character into the isomeric state. The other three transitions can be interpreted as merely the decay of the 5^- two-neutron core state (2100.8 keV) to the 4^+ two-phonon (1632.8 keV), or to the 2^+ one-phonon (839.4 keV) core state.

The quantitative question of why the $\frac{15}{2}^-$ state is lower in energy than the other possible $\pi\nu_1\nu_2$ configurations (the 5^- plus $1g_{7/2}$ coupled to $\frac{17}{2}^-$ in par-

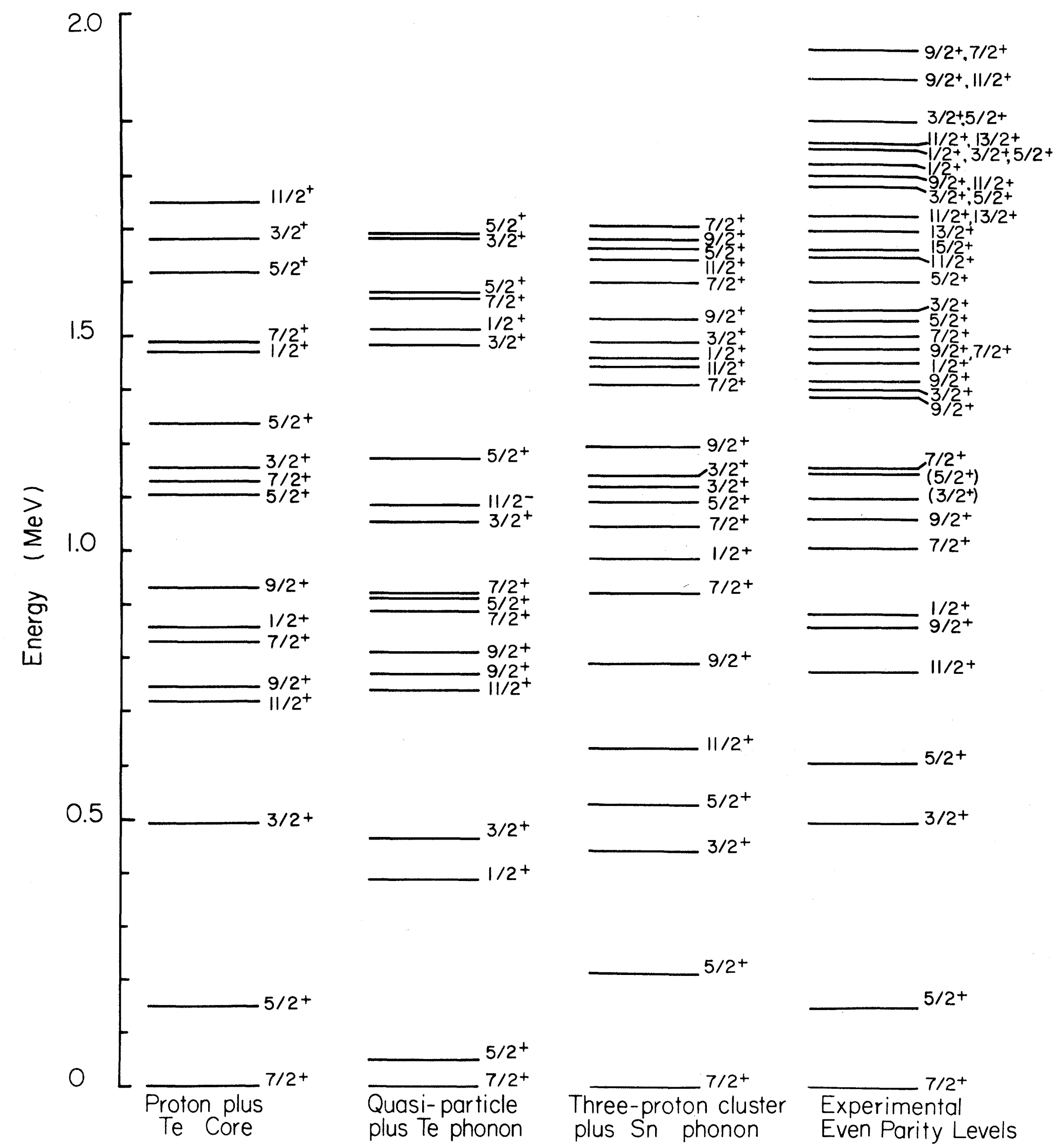

FIG. 7. Comparison between the experimental even parity states in ^{131}I (this work and Ref. 6) and three different theoretical calculations (Refs. 7, 11, 49).

TABLE VII. Calculated g factors for the possible one-proton-two-neutron configurations which result in a spin and parity value of $\frac{15}{2}^-$.

Configuration: Proton, Neutrons	Calculated g factor
$[1g_{7/2}, (1h_{11/2}, 3s_{1/2})5^-]\frac{15}{2}^-$	+0.16
$[1g_{7/2}, (1h_{11/2}, 3s_{1/2})6^-]\frac{15}{2}^-$	−0.32
$[1g_{7/2}, (1h_{11/2}, 2d_{3/2})4^-]\frac{15}{2}^-$	−0.17
$[1g_{7/2}, (1h_{11/2}, 2d_{3/2})5^-]\frac{15}{2}^-$	−0.06
$[1g_{7/2}, (1h_{11/2}, 2d_{3/2})6^-]\frac{15}{2}^-$	−0.01
$[1g_{7/2}, (1h_{11/2}, 2d_{3/2})7^-]\frac{15}{2}^-$	+0.01
$[2d_{5/2}, (1h_{11/2}, 3s_{1/2})5^-]\frac{15}{2}^-$	+0.60
$[2d_{5/2}, (1h_{11/2}, 3s_{1/2})6^-]\frac{15}{2}^-$	−0.04
$[2d_{5/2}, (1h_{11/2}, 2d_{3/2})5^-]\frac{15}{2}^-$	+0.40
$[2d_{5/2}, (1h_{11/2}, 2d_{3/2})6^-]\frac{15}{2}^-$	+0.30
$[2d_{5/2}, (1h_{11/2}, 2d_{3/2})7^-]\frac{15}{2}^-$	+0.15

TABLE VIII. Distribution of the odd parity states of ^{131}I predicted by zeroth-order coupling between the odd parity ^{130}Te core states in Table V and the $1g_{7/2}$ and $2d_{3/2}$ shell-model orbitals and by the coupling of the one-phonon excitation with the $1h_{11/2}$ orbital.

J^π	$\pi\nu_1\nu_2$ states	Octupole states	Phonon states
$\frac{1}{2}^-$	1	2	
$\frac{3}{2}^-$	4	2	
$\frac{5}{2}^-$	8	2	
$\frac{7}{2}^-$	10	2	1
$\frac{9}{2}^-$	11	2	1
$\frac{11}{2}^-$	11	2	1
$\frac{13}{2}^-$	11	1	1
$\frac{15}{2}^-$	10		1
$\frac{17}{2}^-$	8		
$\frac{19}{2}^-$	4		
$\frac{21}{2}^-$	1		

ticular) remains to be answered. It is possible that this is the result of admixture of the $\frac{15}{2}^-$ one-phonon plus $1h_{11/2}$ configuration, as there is no possible $\frac{17}{2}^-$ one-phonon state. Apt and Walters have suggested that the admixture of $[\pi 2d_{5/2}, (\nu_1\nu_2)5^-]\frac{15}{2}^-$ configurations may be responsible.

The remaining observed odd parity states may arise from three possible couplings. The 3^- octupole excitation of the core may couple with the $1g_{7/2}$ or $2d_{5/2}$ single proton state. The 2^+ one-phonon Te core excitation may couple with the $1h_{11/2}$ single proton state. Or the odd parity two-neutron states in ^{130}Te may couple to the $1g_{7/2}$ or $2d_{5/2}$ state resulting in a $\pi\nu_1\nu_2$ three quasiparticle configuration. The distribution of the resulting odd parity states is tabulated in Table VIII. In Fig. 8 we show schematically the result of these couplings using only the observed odd parity levels in the ^{130}Te core.[42, 43, 45] An examination of Table VIII and Fig. 8 indicates that the phonon and octupole states alone cannot account for the observed density of odd parity states, and furthermore that they would be expected to be at considerably higher excitation energies than the observed levels. Thus, although some configuration mixing undoubtedly occurs, the observed odd parity levels are primarily describable as $\pi\nu_1\nu_2$ three quasiparticle configurations. Couplings using only the observed 5^- (2100.8 keV) and 7^- (2146.0 keV) states in the ^{130}Te core can account for the observed density of states, and many more high-spin states could result from the unobserved 4^-, 5^-, and 6^- states noted in Table VIII.

From an examination of the possible decay paths, we conclude that there should be two principal mechanisms for the β decay of $\frac{11}{2}^-$ $^{131}Te^m$. In one, the valence $1h_{11/2}$ neutron undergoes an allowed transition to the final proton orbital $1h_{11/2}$ (1646.01 keV), or a first forbidden or first forbidden unique transition to single particle pieces of lower lying states. The other mechanism is decay to the three-particle $\pi\nu_1\nu_2$ states, viewed as a single-particle transition from a core neutron orbital (ν_2) near the Fermi level to the final state proton orbital (π), with the valence $1h_{11/2}$ neutron (ν_1) remaining unchanged. In this case the strongest β transitions should be the allowed transitions from an initial state with the configuration

$$[(\nu_2 2d_{3/2}, \nu_2 2d_{3/2})0^+, \nu_1 1h_{11/2}]\tfrac{11}{2}^-$$

to the 12 odd parity states with configurations

$$[\pi 2d_{5/2}, (\nu_1 1h_{11/2}, \nu_2 2d_{3/2})4^-, 5^-, 6^-, 7^-]_{9/2^-,\ 11/2^-,\ 13/2^-}.$$

We have, in fact, observed major β-decay branches to four $\frac{9}{2}^-$, three $\frac{11}{2}^-$, and three $\frac{13}{2}^-$ states, although it would be somewhat presumptuous to identify these states as having the exact configurations given above.

The β-decay branch to the $1h_{11/2}$ single quasiparticle proton state is relatively weak ($\log ft = 7.7$) compared to the branches to the $\pi\nu_1\nu_2$ states ($\log ft = 5.8$–6.8). The equivalent β branch to the $\pi 1h_{11/2}$ state is also small in the decay of $\frac{11}{2}^-$ $^{129}Te^m$, having a $\log ft$ value of 8.4.[3, 4] In view of the occupancy of the parent $\nu 1h_{11/2}$ states, the emptiness of the daughter $\pi 1h_{11/2}$ states, and the relative purity of both parent and daughter states as exhibited in the (^{3}He, d) and (d,p) reactions, the source of the hindrance is not easily understood. This same hindrance is seen in ^{125}Sn β decay,[53] and the electron capture[54] of the $\nu 1h_{11/2}$ isomer of ^{119}Te to the $\pi 1h_{11/2}$ state at 1365.8 keV in ^{119}Sb with a logft of 6.4 is somewhat faster but still slower than decay to the $\pi\nu_1\nu_2$ states in ^{119}Sb near 2 MeV. These hindrances are consistent with the general slowness of the first-forbidden decay of the $1h_{11/2}$ neutron to the positive parity states in Sb and I nuclides where logft values $\geq$10.0 are quite common.

Our inability to observe a β branch to the $\frac{1}{2}^+$

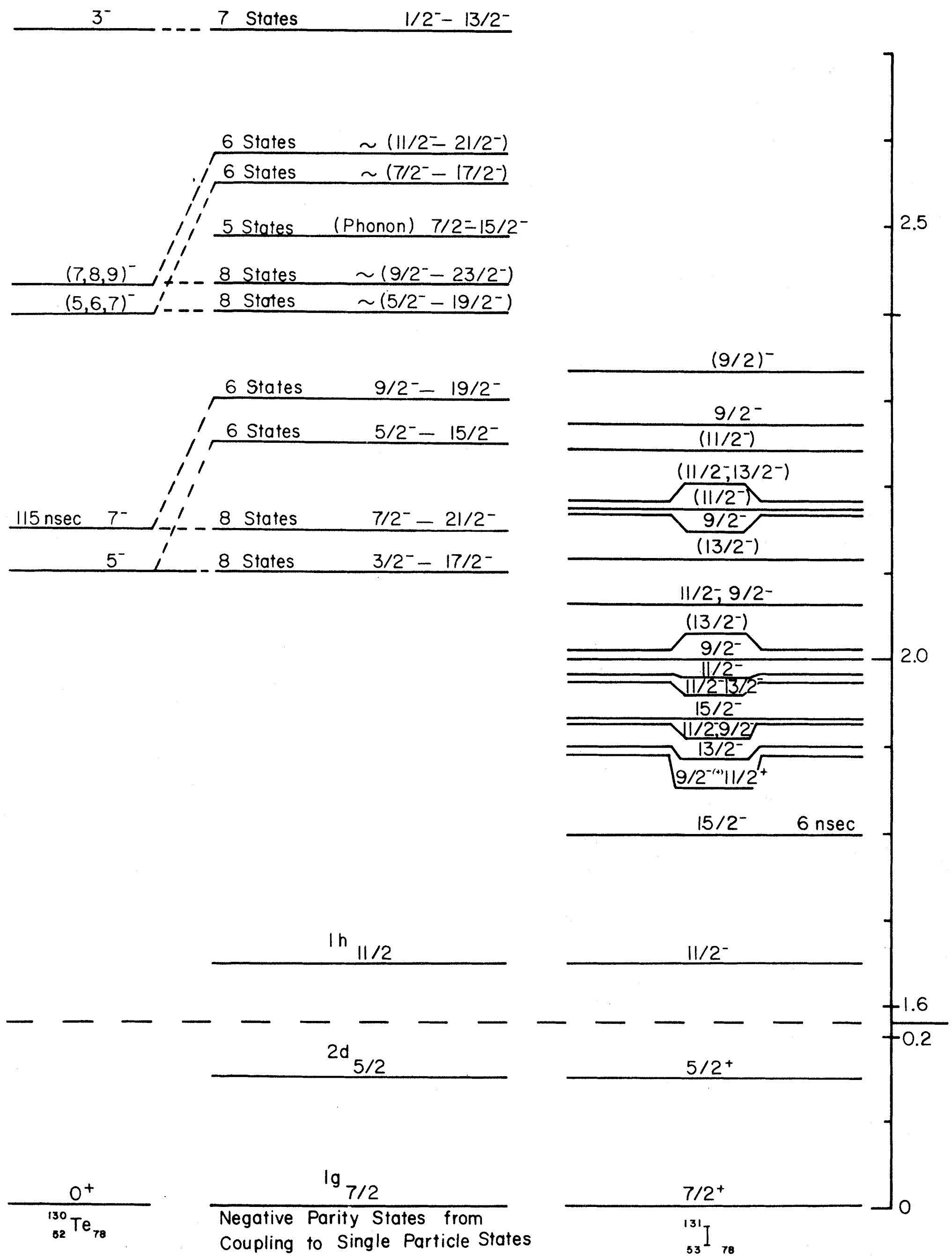

FIG. 8. Odd parity states of ^{131}I (this work). On the left are the odd parity states observed in the ^{130}Te core (Refs. 42, 43, 45), and in the center are the possible states resulting from a zeroth-order coupling of the core to the $1g_{7/2}$ and $2d_{5/2}$ states as well as the 2+ one-phonon core excitation to the $1h_{11/2}$ state.

state observed at 1718 ± 10 keV in the (^{3}He, d) study is consistent with the earlier observations of very hindered β transitions to the $\frac{1}{2}^+$ levels in $^{127, 129, 131}$I from the respective $^{127, 129, 131}$Te $\frac{3}{2}^+$ isomers.[1–4, 18] Although the β transition is l forbidden ($\Delta l = 2$), the observed $\log ft$ values are much higher than l forbiddenness is expected to contribute (e.g., the $\log ft$ of 6.4 for decay[26] of $\frac{7}{2}^+$ ^{131}I to the $\frac{5}{2}^+$ 364-keV state in ^{131}Xe). The hindrance is also surprising in view of the single-particle character of the states involved and, in fact, appears to be directly correlated with the amount of single particle character.

The γ branching of the 1427.14 keV $\frac{5}{2}^+$ level is interesting, as $E2$ transitions of nearly equal intensity are observed to the $\frac{9}{2}^+$ and $\frac{1}{2}^+$ states at 852.21 and 876.72 keV, respectively. The branching of the other lower levels can be accounted for by assuming $E2$ transitions with similar enhancements to the two pure transitions and little $M1$ contribution. The transitions to the 1146.95 and 1148.9 keV levels, however, require either $E2$ enhancements of 10 and 60 times, respectively, or sizeable $M1$ contributions. We also note the absence ($I_\gamma < 0.002$) of a 1444.05-keV transition to the $\frac{7}{2}^+$ ground state from the $\frac{3}{2}^+$ 1444.05 keV state. This may be compared with the 438.3-keV $E2$ branch to the $\frac{7}{2}^+$ state at 1005.76 keV, and a hindrance of ~1500 for the 1444.05-keV transition relative to the 438.3-keV transition is deduced.

The three-proton cluster plus quadrupole vibrator (Sn core) model gives the best fit to the even parity levels. However, there is evidence that these levels have a large amount of single proton plus Te core character. This is seen in the odd-A iodine level systematics (Fig. 5) which show a general rise in the level positions paralleling the rise of the 2^+ state of the even-even Te nuclides with increasing neutron number. The Sn core 2^+ states, in contrast, change very little with neutron number. In addition, the theoretical three-proton cluster work has placed a $\frac{15}{2}^+$ level near 800 keV with a sizeable $(1g_{7/2})^3$ $\frac{15}{2}^+$ component.[55] As we note that there is no $(1g_{7/2})^3$ $\frac{13}{2}^+$ state,[56] and as the $\frac{13}{2}^+$ and $\frac{15}{2}^+$ states lie close to each other and near the position of the 4^+ state in the ^{130}Te core (Fig. 6), we suggest that the $(1g_{7/2})^3$ $\frac{15}{2}^+$ configuration is not important below ~2 MeV, and that the observed $\frac{15}{2}^+$ and $\frac{13}{2}^+$ levels might be better described in terms of a single proton coupled to the Te core two-phonon excitation. Thus a model based on both three-particle-plus-Sn-core and single-particle-plus-Te-core configurations might be expected to give the most accurate fit to ^{131}I levels. To fit the odd parity levels, this model would undoubtedly have to include a wider basis of states than have so far been considered, specifically the $1h_{11/2}$ proton state, the octupole states, and the $\nu_1\nu_2$ configurations.

Note added in proof: Since the submission of this article, a paper has appeared by Fujiwara, Imanishi, and Nishi[57] who report absolute γ intensities for the decay of ^{131}Te and ^{133}Te isomers. For the 149.72-keV γ ray of $^{131}Te^g$ decay, they report an absolute value of 0.87 ± 0.04 γ rays per decay. As the α_K and K/L values[17] have been measured to be 0.21 ± 0.01 and 7.9 ± 0.4, respectively, for the 149.72-keV γ ray, 0.77 is absolutely the upper limit for 149.72-keV γ rays per decay of $^{131}Te^g$. Our measurements combined with the α_K, α_L, and an extrapolated α_M would indicate a value of 0.68 ± 0.03 γ rays per decay of $^{131}Te^g$.

ACKNOWLEDGMENTS

One of the authors, S. V. Jackson, wishes to express his appreciation to the National Science Foundation and to the Gillette Research Corporation for fellowship support while attending the University of Maryland.

The authors wish to express their appreciation to the operating crews of the Livermore pool-type reactor and the National Bureau of Standards reactor for their assistance in performing irradiations, to Mr. N. Smith and Mr. J. Landrum for performing some chemical separations, to Ms. P. Schuster for work with the $\gamma\gamma$-coincidence experiments, and to the University of Maryland Computer Science Center for a grant of computer time on the University of Maryland Univac 1108.

---

†From a dissertation to be submitted to the Graduate School, University of Maryland, by S. V. Jackson, in partial fulfillment of the requirements for the Ph.D. degree in Chemistry.

*Gillette-Harris Research Fellow.

‡Lawrence Livermore Laboratory Visitor.

§Work supported in part by the U.S. Atomic Energy Commission under Contract No. AT(40-1)-4028.

¶Work performed under the auspices of the U.S. Atomic Energy Commission and supported by Defense Advance Research Projects Agency.

[1]K. E. Apt, W. B. Walters, and G. E. Gordon, Nucl. Phys. A152, 344 (1970).

[2]K. E. Apt, Ph.D. thesis, Massachusetts Institute of Technology, 1971 (unpublished).

[3]W. B. Walters and R. A. Meyer, Bull. Am. Phys. Soc. 17, 907 (1972).

[4]L. G. Mann, R. A. Meyer, and W. B. Walters, private communication.

[5]J. De Raedt, M. Rots, and H. Van de Voorde, Phys.

Rev. C 9, 2391 (1974).
[6]R. L. Auble, J. B. Ball, and C. B. Fulmer, Phys. Rev. 169, 955 (1968).
[7]M. L. Rustgi, J. G. Lucas, and S. N. Mukherjee, Nucl. Phys. A117, 321 (1968).
[8]V. Parr, Nucl. Phys. A211, 29 (1973).
[9]G. Vanden Berghe, Z. Phys. 266, 139 (1974).
[10]S. Kuriyama, T. Marumori, and K. Matsuyanagi, Institute for Nuclear Studies, Tokyo, Report No. INS-204, 1973 (unpublished).
[11]R. Almar, O. Civitarese, and F. Krmpotić, Phys. Rev. C 8, 1518 (1973).
[12]E. Hebb, Phys. Rev. 97, 987 (1955).
[13]A. Badescu, K. P. Mitrofanov, A. A. Sorokin, and V. S. Shpinel, Izv. Akad. Nauk SSSR Ser. Fiz. 23, 1434 (1959) [transl.: Bull. Acad. Sci. USSR, Phys. Ser. 23, 1424 (1959)].
[14]A. Badescu, O. M. Kalinkina, K. P. Mitrofanov, A. A. Sorokin, N. V. Farafontov, and V. S. Shpinel, Zh. Eksp. Teor. Fiz. 40, 91 (1961) [transl.: Sov. Phys.—JETP 13, 65 (1961)].
[15]S. H. Devare, R. M. Singru, and H. G. Devare, Phys. Rev. 140, B536 (1965).
[16]L. M. Beyer, G. Berzins, and W. H. Kelly, Nucl. Phys. A93, 456 (1967).
[17]L. M. Beyer and W. H. Kelly, Nucl. Phys. A104, 274 (1967).
[18]E. S. Macias and W. B. Walters, Nucl. Phys. A161, 471 (1971).
[19]K. E. Apt, Los Alamos Scientific Laboratory, private communication.
[20]P. N. Tandon and H. G. Devare, Nucl. Phys. A102, 203 (1967).
[21]S. V. Jackson, W. B. Walters, and R. A. Meyer, in Proceedings of the 167th ACS National Meeting, Division of Nuclear Chemistry and Technology, 1974 (unpublished), Abstract 32.
[22]S. V. Jackson, W. B. Walters, and R. A. Meyer, Bull. Am. Phys. Soc. 19, 501 (1974).
[23]W. B. Walters, C. E. Bemis, and G. E. Gordon, Phys. Rev. 140, B268 (1965).
[24]D. C. Camp, in *Proceedings of the International Conference on Radioactivity in Nuclear Spectroscopy, Vanderbilt University, Nashville, Tennessee, 11–15 August, 1969*, edited by J. H. Hamilton and J. C. Manthuruthil (Gordon and Breach, New York, 1972), Vol. I, p. 135.
[25]R. Gunnink and J. B. Niday, UCRL Report No. 51061, Vols. I–IV, 1971 and 1972 (unpublished).
[26]R. A. Meyer, F. Momyer, and W. B. Walters, Z. Phy. 268, 387 (1974).
[27]V. E. Viola, Jr., G. E. Gordon, and W. B. Walters, Progress report No. MNC-4028-0012, 1973 (unpublished), p. 95.
[28]S. H. Devare, P. N. Tandon, and H. G. Devare, Phys. Rev. 131, 1750 (1963).
[29]R. S. Hager and E. C. Seltzer, Nucl. Data A4, 1 (1968).
[30]A. H. Wapstra and N. B. Gove, Nucl. Data A9, 267 (1971).
[31]A. Graue, E. Jastad, J. R. Lien, P. Torvund, and W. H. Moore, Nucl. Phys. A103, 209 (1967).
[32]N. F. Verster, G. J. Nijgh, R. Van Lieshout, and G. J. Bakker, Phys. Acta 17, 637 (1951).
[33]D. Rose, G. Hinman, and L. G. Lang, Phys. Rev. 86, 863 (1952).
[34]N. B. Gove and M. J. Martin, Nucl. Data A10, 205 (1971).
[35]R. L. Auble, Nucl. Data B8, 77 (1972).
[36]D. J. Horen, Nucl. Data B8, 123 (1972).
[37]G. M. Lederer, J. M. Hollander, and I. Perlman, *Table of Isotopes* (Wiley, New York, 1968), 6th ed.
[38]M. Goldhaber and A. W. Sunyar, in *Alpha-, Beta-, and Gamma-Ray Spectroscopy,* edited by K. Siegbahn (North-Holland, Amsterdam, 1965).
[39]S. A. Moszkowski, in *Alpha-, Beta-, and Gamma-Ray Spectroscopy* (see Ref. 38).
[40]R. Seltz and N. M. Hintz, University of Minnesota Report No. COO-1265-116, 1971 (unpublished), p. 97.
[41]A. Kerek, Nucl. Phys. A185, 497 (1972).
[42]A. Kerek, P. Carle, and J. McDonald, Nucl. Phys. A198, 466 (1972).
[43]A. Kerek, P. Carle, and S. Borg, Nucl. Phys. A224, 367 (1974).
[44]R. L. Auble, Nucl. Data B9, 157 (1973).
[45]H. R. Hiddleston and C. P. Browne, Nucl. Data B13, 133 (1974).
[46]F. E. Bertrand, Nucl. Data B7, 419 (1972).
[47]F. E. Bertrand, Nucl. Data B10, 91 (1973).
[48]R. L. Auble, Nucl. Data B9, 125 (1973).
[49]L. S. Kisslinger and R. A. Sorenson, Rev. Mod. Phys. 35, 853 (1963).
[50]K. E. Apt and W. B. Walters, Phys. Rev. Lett. 26, 1189 (1971).
[51]K. E. Apt and W. B. Walters, Phys. Rev. C 9, 310 (1974).
[52]E. R. Flynn, J. G. Beery, and A. G. Blair, Nucl. Phys. A154, 225 (1970).
[53]E. S. Macias and W. B. Walters, Nucl. Phys. A160, 274 (1970).
[54]G. Graeffe, E. J. Hoffman, and D. G. Sarantites, Phys. Rev. 158, 1183 (1967).
[55]G. Vanden Berghe, in Seminaire voor Wiskundige Natuurkunde, Gent, Belgium, 1973 (unpublished).
[56]M. A. Preston, *Physics of the Nucleus* (Addison-Wesley, Reading, Mass., 1962).
[57]I. Fujiwara, N. Imanishi, and T. Nishi, J. Inorg. Nucl. Chem. 36, 1921 (1974).