PHYSICAL REVIEW C VOLUME 23, NUMBER 1 JANUARY 1981

(t,d) reaction on ^{124}Te, ^{126}Te, ^{128}Te, and ^{130}Te nuclei

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(Received 6 May 1980)

Differential cross section angular distributions have been measured for levels below 2.5 MeV in each residual nucleus in the ^{124,126,128,130}Te$(t,d)^{125,127,129,131}$Te reactions at $E_t = 16$ MeV. The reaction products were analyzed in an Enge split-pole magnetic spectrograph and were detected by a delay-line counter at the focal plane. The deuteron energy resolution obtained was between 13 and 15 keV full width at half maximum depending on the target used. The deuteron spectra from these Te(t,d) reactions are quite similar to the proton spectra obtained in the (d,p) reactions on the same target nuclei. Several new levels were, however, populated and most of them have L values ≥ 2. Distorted-wave Born-approximation analyses of these Te(t,d) reaction data have been performed and spectroscopic factors extracted. These compare well with the spectroscopic factors obtained from previous (d,p) experiments except for levels in ^{125}Te. In this case the present values are $\sim 25\%$ lower than those obtained in the (d,p) reaction; however, they are in good agreement with the spectroscopic factors obtained in (t,d) and (d,p) reactions on the other tellurium nuclei.

[NUCLEAR REACTIONS ^{124,126,128,130}Te$(t,d)^{125,127,129,131}$Te, E_t=16 MeV, measured $\sigma(E_d, \theta)$, resolution 13–15 keV, DWBA calculations, deduced L transfers, spectroscopic factors.]

I. INTRODUCTION

Several experimental aspects such as level spacing, accessibility from different relatively simple stable and radioactive targets, etc., have prompted many different studies of odd tellurium nuclei using diverse techniques. For a complete review of these experimental works the reader is referred to Ref. 1. However, some of the most recent works and the works that are pertinent to the present study include (1) the particle transfer reactions such as (d,p) studies,[2,3,5-9] (d,t) studies,[3,4] and a $(^3\text{He},\alpha)$ study,[4] and (2) the γ-ray studies[10-17] using different techniques. Extensive theoretical calculations have also been done to understand the structure of these odd Te nuclei. In a shell model picture, these $^{123-131}_{52}$Te$_{71-79}$ nuclei have two protons outside the closed shell at $Z=50$ and are 3 to 11 neutrons away from the closed neutron shell at $N=82$. This has made shell model calculations or their extensions relatively simple.[4,10,18-22] All of these calculations had various degrees of success in explaining the structure of these odd Te nuclei. Alternative methods, such as a particle-plus-asymmetric-rotor model[23] and cluster model[24] calculation, had some success in explaining the level structures of the neighboring nuclei. The main features of the level schemes of these odd tellurium isotopes have been discussed in Refs. 11 and 16.

To the best of our knowledge this is the first (t,d) reaction study on Te nuclei. Except for the ^{126}Te$(^3\text{He},\alpha)^{125}$Te study of Ref. 4, the present experiment was carried out with higher incident momentum than used in previous studies, and it was expected that more states with higher L and J values than those seen in previous studies would be populated.

II. EXPERIMENTAL DETAILS

The ^{124,126,128,130}Te$(t,d)^{125,127,129,131}$Te reactions were studied at the McMaster University Tandem Accelerator Laboratory using a 16 MeV triton beam from the sputter source and FN tandem system. The maximum beam current on target was ~150 nA. The reaction products were analyzed in an Enge split-pole magnetic spectrograph and were detected by a Michigan State University type high resolution position-sensitive proportional counter[25] at the focal plane. This counter consists of a delay-line counter at the front and a single wire proportional counter at the back separated by a thin window. The delay-line counter gives the position (energy) of the particles and the back counter provides the ΔE (mass) signals. These are collected by a PDP-9 computer which sorted the data into position spectra for different masses. Typical deuteron spectra from these reactions are shown in Fig. 1. The spectra of the ^{127}Te, ^{129}Te, and ^{131}Te nuclei have been adjusted to line up peak No. 1 with that of ^{125}Te. The peaks are labeled and their characteristics, such as excitation energy, spin, parity, etc., are discussed in Sec. IV.

The Enge magnetic spectrograph was calibrated by using the 8.784 MeV alpha particles from a radioactive ^{212}Po source. This calibration procedure has been described by Burke and Balogh.[26] The

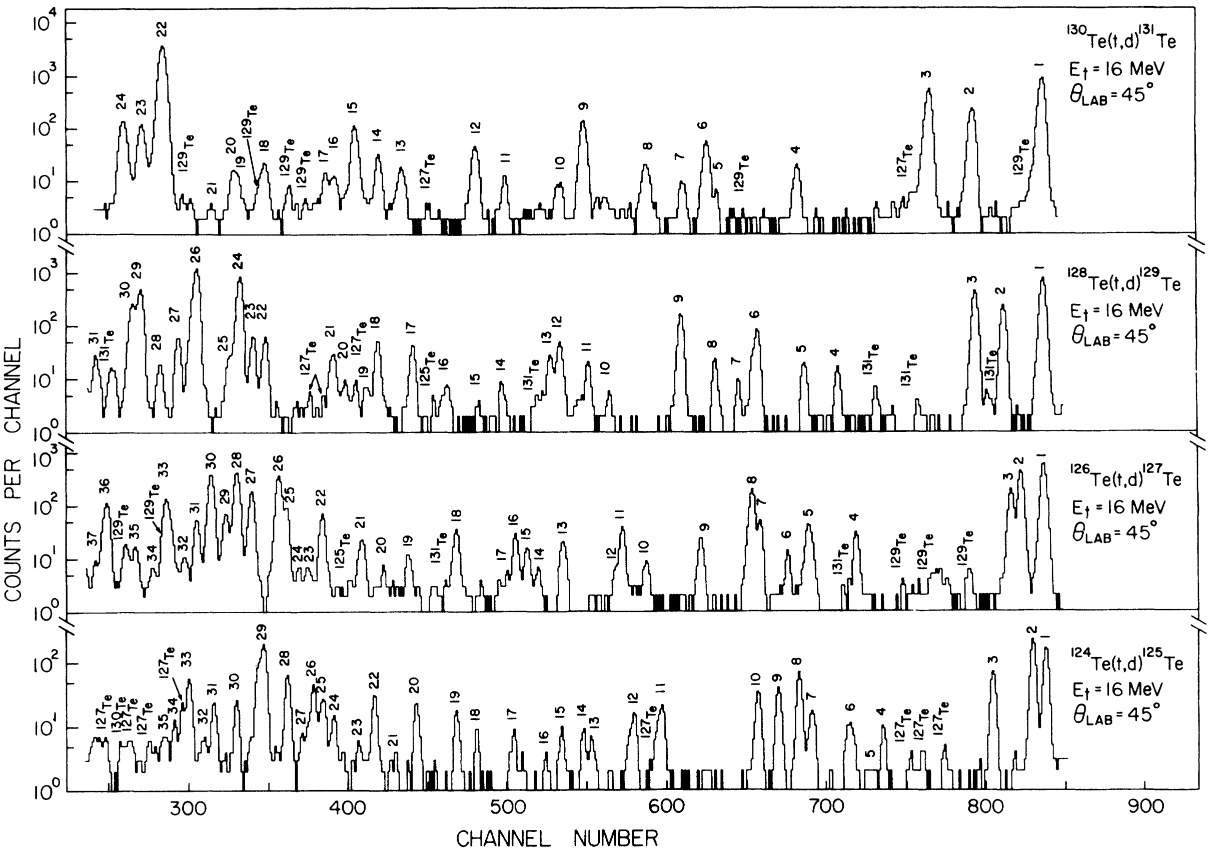

FIG. 1. Sample spectra from the ^{124,126,128,130}Te$(t,d)^{125,127,129,131}$Te reactions at E_t =16 MeV and θ_{lab} =45°. Each peak ascribed to the indicated reaction is identified with a number which also appears in the tables and the text.

excitation energies determined from our experiments have errors of ~5 keV, mainly due to the uncertainty in determining the peak position. The overall resolution for the deuteron spectra was ~15 keV full width at half maximum (FWHM). Several new levels and levels that were not observed in (d,p) reactions were populated in these (t,d) reactions. Otherwise the relative intensities of different levels in the deuteron spectra are similar to those observed in proton spectra from (d,p) reactions[2,5,7,8] leading to the same residual nuclei. The excitation energies of levels in the final nuclei agree within their uncertainties (± 5 keV) with those obtained in the (d,p) studies of Refs. 2, 5, 7, and 8.

The target materials were purchased from the Isotopes Sales Division of the Oak Ridge National Laboratory. Their isotopic abundances, as quoted by the supplier, were 96.21, 98.69, 99.19, and 99.49% for ^{124}Te, ^{126}Te, ^{128}Te, and ^{130}Te isotopes, respectively. These metallic tellurium isotopes were vacuum evaporated onto 20 μg/cm^2 carbon backings. The target thicknesses, determined to ~15%, were 30, 110, 100, and 160 μg/cm^2 for the ^{124}Te, ^{126}Te, ^{128}Te, and ^{130}Te targets, respectively. These were determined by measuring the elastically scattered tritons at $\theta_{\text{lab}} = 30°$ and using the elastic cross sections calculated by the distorted-wave Born approximation (DWBA) computer code[27] DWUCK4 with optical model parameter set *T*1 of Table I. The absolute Te(t,d) cross sections were determined by comparing the number of counts in the peaks in the position spectra with the number of elastically scattered particles detected by the monitor detector in the same run. The peak areas from the position spectra were obtained using a peak fitting program working on the McMaster PDP-15 computer. The uncertainties of the Te(t,d) absolute cross sections are estimated to be ~20%. This is mainly due to the uncertainties in target thickness.

III. DWBA ANALYSIS

Zero-range DWBA calculations were performed with the computer code **DWUCK4**[27] to fit the measured angular distributions. The calculations with

TABLE I. Optical model parameters.

Set	Ref.	V_R (MeV)	r_R (fm)	a_R (fm)	λ (Thomas)	W_V (MeV)	$4W_D$ (MeV)	r_I (fm)	a_I (fm)	r_C (fm)
$T1$	29	153.0	1.24	0.70		16.42		1.42	0.89	1.25
$T2$	30	153.0	1.35	0.889		20.8		1.42	0.889	1.25
$T3$	Present work	153.0	1.30	0.76		18.6		1.42	0.89	1.25
$D1$	31	98.28	1.15	0.81			72.96	1.34	0.68	1.15
$A1$	31	219.3	1.395	0.549		31.8		1.395	0.549	1.30
$B1$		a	1.25	0.65	25.0					

[a] Adjusted to reproduce the neutron binding energy.

the triton optical model parameter set $T1$ and deuteron set $D1$ of Table I produced the best fits to the $^{A}\mathrm{Te}(t,d)^{A+1}\mathrm{Te}$ ($A=124$, 126, 128, and 130) angular distributions. These are shown by the solid line fits in Fig. 2. However, triton parameter set $T2$ when used with the α-parameter set $A1$ produced the best fits to the $^{A}\mathrm{Te}(t,\alpha)^{A-1}\mathrm{Sb}$ angular distributions.[28] The triton optical model parameter sets $T1$ and $T2$ are from Refs. 29 and 30, respectively. $T3$ is a compromise set between $T1$ and $T2$, which yielded equally good fits to both the Te(t,d) and Te(t,α) angular distributions. The fits with pa-

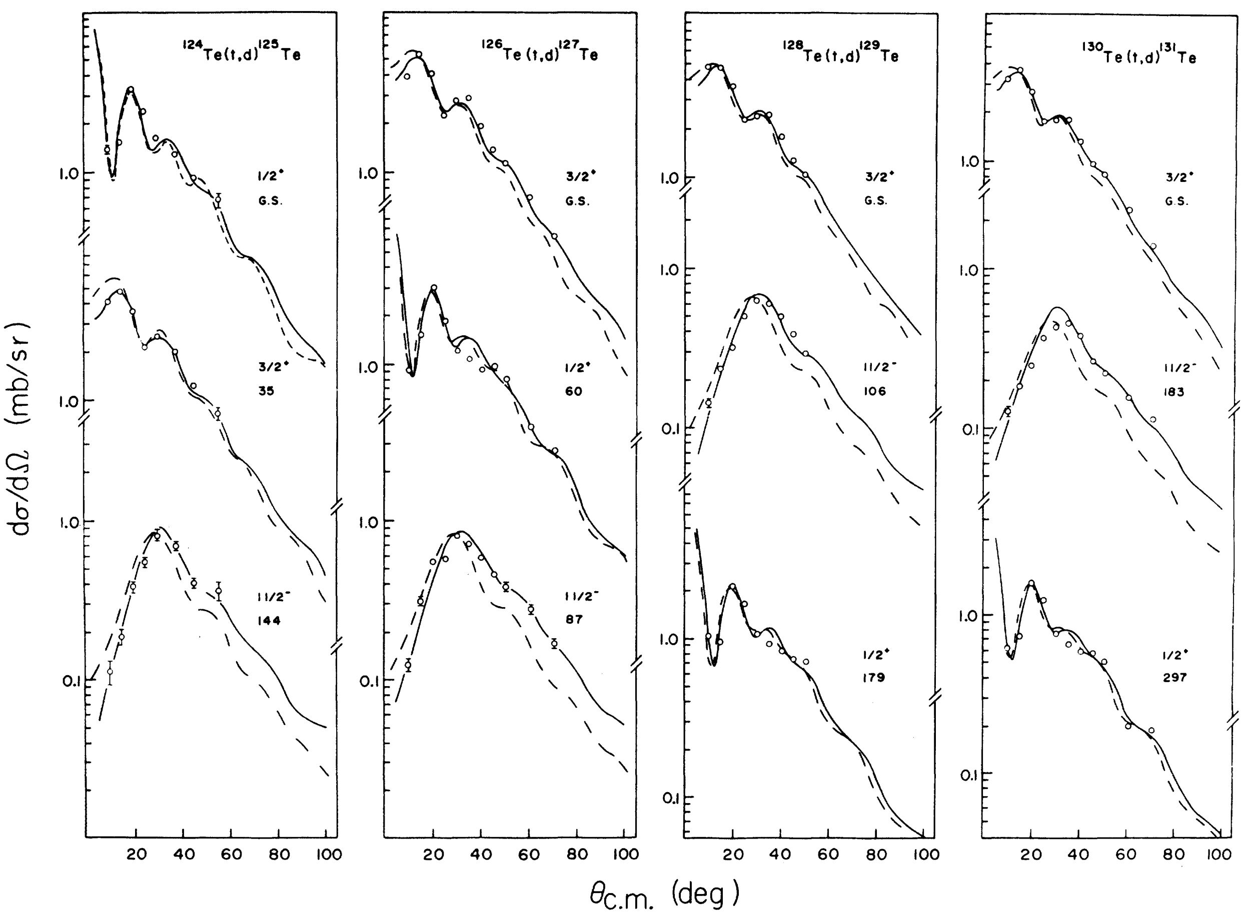

FIG. 2. The differential cross section angular distributions for the first three levels in each residual nucleus in the $^{124,126,128,130}\mathrm{Te}(t,d)^{125,127,129,131}$ Te reactions. The J^{π} value and excitation energy (keV) of each state are also indicated. The solid and dashed lines are DWBA calculations using optical model parameter sets T1D1B1 and T3D1B1 of Table I, respectively.

rameter sets $T3D1$ are shown by the dashed lines in Fig. 2. The effects of different deuteron parameter sets on the Te(t,d) angular distributions were found to be negligible compared to those of different triton optical model parameters.

The J dependence in these ^{A}Te$(t,d)^{A+1}$Te angular distribution shapes is almost nonexistent and one cannot identify the J value of a state from DWBA analysis of these data alone. However, the shapes of these angular distributions have a distinct L dependence. In particular the positions of the first diffraction maximum and minimum appear at different angles for different L transfers. This is a distinct advantage of the present ^{A}Te$(t,d)^{A+1}$Te study over the sub-Coulomb or near Coulomb (d,p) reactions, which do not show such prominent L dependence. The spectroscopic factors for a neutron transfer, S_n, are also obtained from these calculations. The predicted cross sections are related to the (t,d) experimental cross sections by

$$\sigma_{ex} = \tfrac{3}{2} D_0^2 S_n \sigma_{th} .$$

We use the value of $D_0^2 = 3.47 \times 10^4$ MeV^2 fm^3 from Ref. 32. These spectroscopic factors are discussed along with the other results in the next section, where the (t,d) reactions on each target are dealt with individually.

IV. RESULTS AND DISCUSSION

The angular distributions and their DWBA fits for the first three levels in each residual nucleus are shown in Fig. 2. Some additional angular distributions and their DWBA fits are also presented in Fig. 3 for ^{124}Te$(t,d)^{125}$Te; in Fig. 4 for ^{126}Te$(t,d)^{127}$Te; in Fig. 5 for ^{128}Te$(t,d)^{129}$Te; and in Fig. 6 for the ^{130}Te$(t,d)^{131}$Te reaction. Maximum cross sections and other information for these targets are shown in Tables II–V, respectively. The peak numbers in each table are the same as in the relevant spectrum of Fig. 1. Our energies for the levels compare within their uncertainties (± 5 keV) with those of Graue *et al.*[2,5,7,8] and these are recorded in column 2 of each table. The orbital angular momentum of the transferred neutron (l_n) giving the predicted shape which best fits the experimental data is also shown in the tables. Only one J^{π} value is recorded when this is definitely known from previous studies, otherwise $J^{\pi} = l_n \pm \frac{1}{2}$ are recorded. This is due to the fact that there is almost no J dependence in the Te(t,d) angular distributions and J^{π} cannot be determined uniquely from such a study alone. Column 5 of all the tables presents the differential cross sections at the forward-angle diffraction maximum, namely at 20.4, 10.2, 15.3, 20.4, 25.5, and 30.6 degrees (c.m.) for $l_n = 0$, 1, 2, 3, 4, and 5, respectively, as shown in Figs. 2–6. The results of earlier studies are summarized in columns 7–9. The results for each ^{A}Te$(t,d)^{A+1}$Te reaction are now summarized and compared with the results of previous studies.

A. ^{124}Te$(t,d)^{125}$Te

As mentioned earlier, the spectra from the (t,d) and (d,p) reactions leading to the same residual Te nuclei are quite similar. The spins and parities of states in ^{125}Te deduced from the present experiment compare well with those of previous studies. As was the case in other direct reaction studies, we did not see the $\frac{9}{2}^-$, $\frac{15}{2}^-$, and $\frac{19}{2}^-$ levels at 0.3213, 0.8409, and 1.5008 MeV, respectively, observed in γ-ray works.[10-12] At 1.8515 MeV a $\frac{21}{2}^-$ level was observed in γ-ray measurements,[10-12] which is not expected to be populated in (t,d) reactions. However, a level (No. 23) was observed in the present study at 1.853 MeV and this has an $l_n = 2$ angular distribution shape. We also observed levels at 1.242, 1.322, 1.364, 1.754, and 2.376 MeV which were not observed in (d,p) reactions. However, the levels at 1.322 and 1.364 MeV were observed in the $(^3$He$,\alpha)$ reaction by Fernandes and Rao,[4] a level at 1.754 MeV was observed in the (d,d') reaction by Kim and Cohen,[33] and a level at 2.376 MeV was observed in a γ-ray study.[10] This level at 2.376 was previously anticipated to be a $(\frac{19}{2}^+)$, but the present (t,d) angular distribution has a distinctive $l_n = 3$ shape, suggesting either a $\frac{5}{2}^-$ or a $\frac{7}{2}^-$ state. Thus it appears that many of the states, previously seen in ^{125}Te, are in fact close doublets. There are two $\frac{7}{2}^+$ states at 0.636 and 0.642 MeV. Walters and Meyer[11] suggested that the lower, 0.636 MeV, level arises from particle-phonon coupling while the upper, 0.642 MeV, level arises from a $g_{7/2}$-hole configuration. In the present study it is not possible to separate these two peaks if both of them are populated. However, only one narrow peak at 0.642 MeV was populated and this would support the explanation of Walters and Meyer[11] for these $\frac{7}{2}^+$ states.

Kerek *et al.*[10] and Prasad[12] assigned the spin and parity of the 0.526 MeV level as $\frac{9}{2}^-$, whereas Walters and Meyer[11] assigned it as $\frac{7}{2}^-$. The (t,d) angular distribution of this level shows a distinctive $l_n = 3$ transfer shape, favoring the $\frac{7}{2}^-$ assignment of Walters and Meyer.[11] The levels at 0.786 and 2.178 MeV were previously assigned as a $(\frac{3}{2}^+ + \frac{7}{2}^-)$ doublet of states, but their (t,d) angular distributions show $l_n = 3$ and 1 shapes, respectively. The level at 2.105 (No. 29) is a possible triplet and cannot be separated in the present study. However, the angular distribution of this unresolved group shows an $l_n = 3$ transfer shape, which indi-

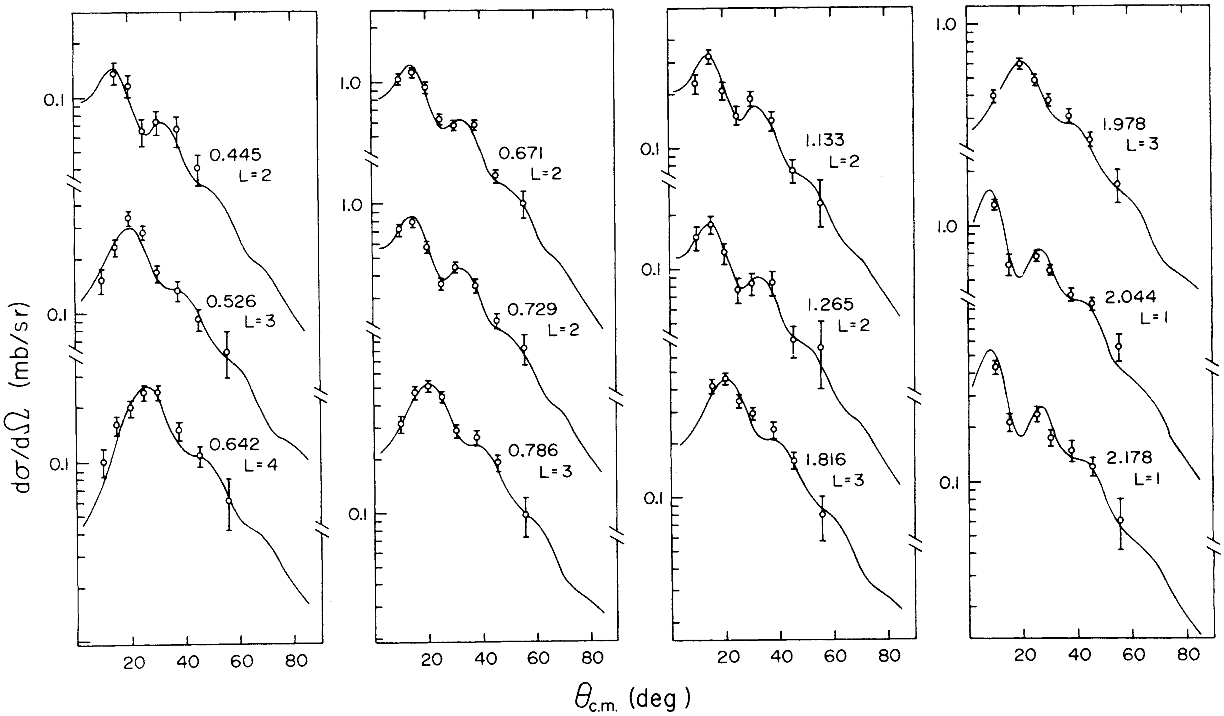

FIG. 3. Some arbitrarily chosen additional angular distributions from the ^{124}Te$(t,d)^{125}$Te reaction. The L transfer and excitation energy (MeV) of each state are indicated. The solid line fits are DWBA calculations using optical model parameter set T1D1B1 of Table I.

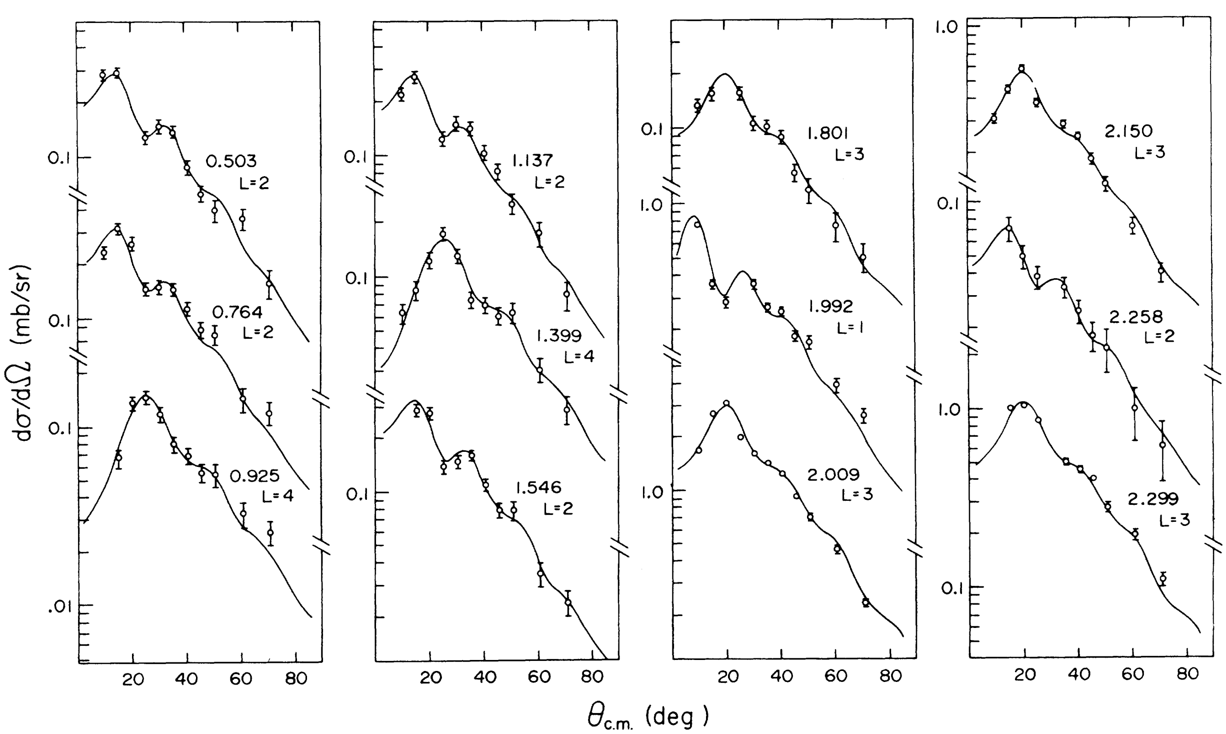

FIG. 4. Some typical angular distributions from the ^{126}Te$(t,d)^{127}$Te reaction. The solid lines are DWBA calculations using optical model parameter set T1D1B1 of Table I.

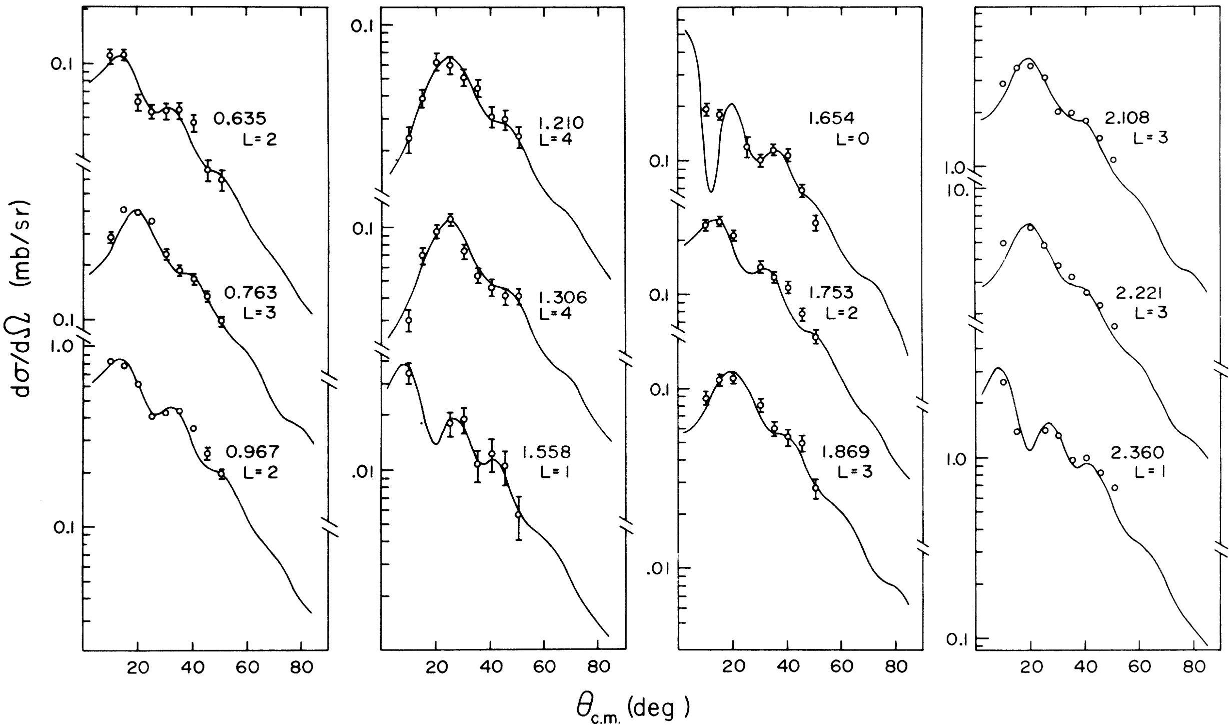

FIG. 5. Additional angular distributions from the ^{128}Te$(t,d)^{129}$Te reaction. The solid lines are DWBA fits using parameter set T1D1B1 of Table I. The excitation energy (MeV) and the L value of the solid line fit of each state are shown.

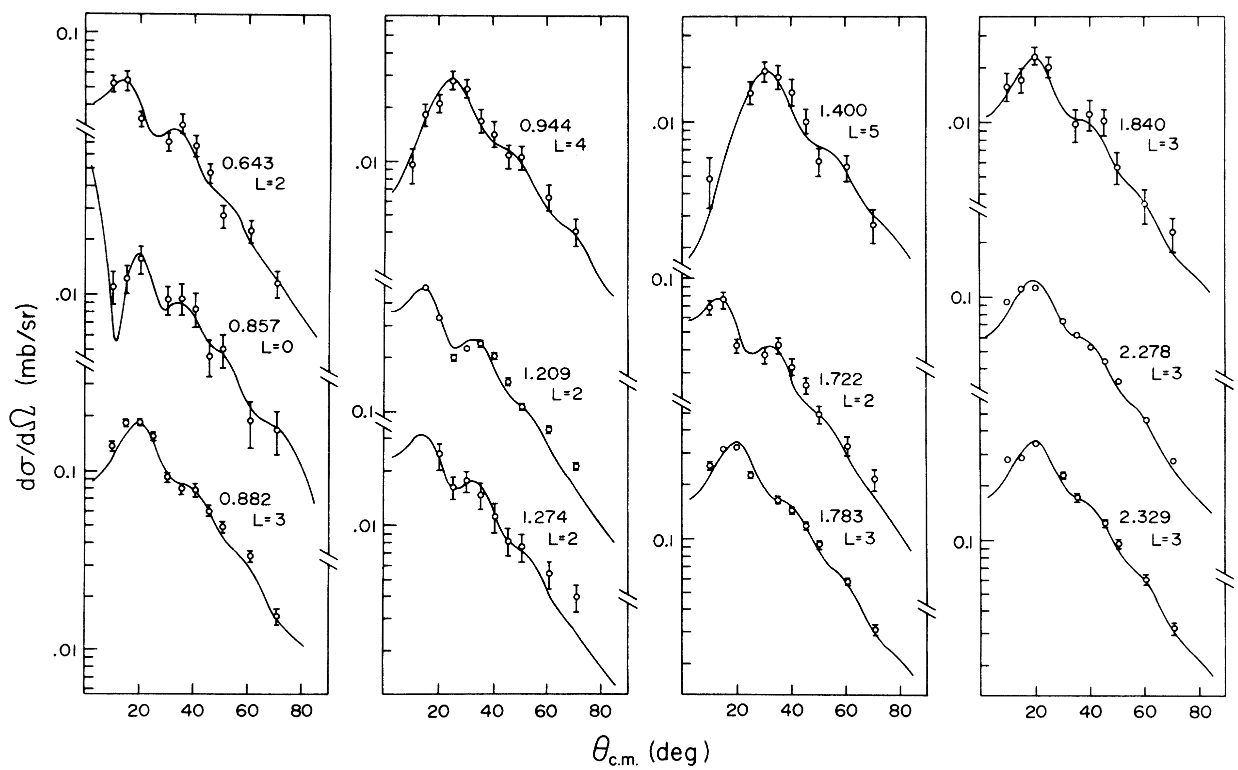

FIG. 6. Additional angular distributions from the ^{130}Te$(t,d)^{131}$Te reaction. The solid lines are DWBA fits using optical model parameter set T1D1B1 of Table I. Each state is labeled with its excitation energy (MeV) and L-transfer shape.

TABLE II. Levels observed in ^{125}Te.

	Present study					Other studies		
Peak No.	E_x (MeV)	l_n	J^π	$d\sigma/d\Omega$ [a] (mb/sr)	Spectroscopic factor S_n	γ-ray [b] studies E_x (MeV)	Direct [c] reactions E_x (MeV)	J^π
1	0.0	0	$\frac{1}{2}^+$	3.273	0.260	0.0	0.0	$\frac{1}{2}^+$
2	0.035	2	$\frac{3}{2}^+$	4.740	0.318	0.0355	0.03	$\frac{3}{2}^+$
3	0.144	5	$\frac{11}{2}^-$	0.799	0.177	0.1448	0.14	$\frac{11}{2}^-$
						0.3212	0.32	$\frac{9}{2}^-$
4	0.445	2	$\frac{3}{2}^+$	0.137	0.009	0.4436	0.44	$\frac{3}{2}^+$
5	0.463	2	$\frac{5}{2}^+$	0.039		0.4634	0.46	$\frac{5}{2}^+$
6	0.526 [d]	3	$\frac{7}{2}^-$	0.336	0.014	0.5254	0.53	$\frac{7}{2}^-$
						0.6362		$\frac{7}{2}^+$
7	0.642	4	$\frac{7}{2}^+$	0.241	0.061	0.6423	0.64	$\frac{7}{2}^+$
8	0.671	2	$\frac{5}{2}^+$	1.131	0.043	0.6714	0.67	$\frac{5}{2}^+$
9	0.729	2	$\frac{3}{2}^+,\frac{5}{2}^+$	0.788	0.053, 0.030	0.7293	0.73	$\frac{3}{2}^+,\frac{5}{2}^+$
10	0.786	3	$\frac{5}{2}^-,\frac{7}{2}^-$	0.506	0.035, 0.020		0.79	$(\frac{3}{2}^+ + \frac{7}{2}^-)$
						0.8409		$\frac{15}{2}^-$
11	1.055	3	$\frac{5}{2}^-,\frac{7}{2}^-$	0.405	0.027, 0.016		1.05	$\frac{5}{2}^-,\frac{7}{2}^-$
12	1.133 [d]	2	$\frac{3}{2}^+,\frac{5}{2}^+$	0.320	0.022, 0.012		1.13	$(\frac{3}{2}^+,\frac{5}{2}^+)$
						1.1918		$\frac{11}{2}^+$
13	1.242	1	$\frac{1}{2}^-,\frac{3}{2}^-$	0.070	0.004, 0.002			
14	1.265	2	$\frac{3}{2}^+,\frac{5}{2}^+$	0.176	0.012, 0.007		1.26	$\frac{3}{2}^+,\frac{5}{2}^+$
						1.3102		
15	1.322	2	$\frac{3}{2}^+,\frac{5}{2}^+$	0.108	0.007, 0.004		1.32	
16	1.364	5	$\frac{9}{2}^-,\frac{11}{2}^-$	0.030	0.013, 0.005		1.37	
17	1.435	2	$\frac{3}{2}^+,\frac{5}{2}^+$	0.121	0.008, 0.005		1.43	$\frac{3}{2}^+,\frac{5}{2}^+$
						1.5008		$\frac{19}{2}^-$
18	1.530	2	$\frac{3}{2}^+,\frac{5}{2}^+$	0.090	0.006, 0.03		1.53	
						1.5703		$\frac{15}{2}^+$
19	1.584	(0)	$(\frac{1}{2}^+)$	0.090	(0.005)		1.58	$\frac{1}{2}^+$
20	1.698	(1)	$(\frac{1}{2}^-,\frac{3}{2}^-)$	0.580	(0.043, 0.020)		1.70	$\frac{1}{2}^-,\frac{3}{2}^-$
							1.74	$\frac{7}{2}^+$
21	1.754	2	$\frac{3}{2}^+,\frac{5}{2}^+$	0.060	0.004, 0.002		1.75	
22	1.816	3	$\frac{5}{2}^-,\frac{7}{2}^-$	0.451	0.028, 0.016		1.82	$(\frac{5}{2}^-,\frac{7}{2}^-)$
23	1.853	2	$\frac{3}{2}^+,\frac{5}{2}^+$	0.101	0.007, 0.004	1.8515		$\frac{21}{2}^{(-)}$
24	1.925	3	$\frac{5}{2}^-,\frac{7}{2}^-$	0.267	0.016, 0.010		1.92	$(\frac{5}{2}^-,\frac{7}{2}^-)$
25	1.954	(1)	$(\frac{1}{2}^-,\frac{3}{2}^-)$	0.694	(0.056, 0.026)		1.95	$\frac{1}{2}^-,\frac{3}{2}^-$
26	1.978	3	$\frac{5}{2}^-,\frac{7}{2}^-$	0.596	0.036, 0.021		1.98	$\frac{5}{2}^-,\frac{7}{2}^-$
27	2.005	(1)	$(\frac{1}{2}^-,\frac{3}{2}^-)$	0.230	(0.019, 0.009)		2.00	$\frac{1}{2}^-,\frac{3}{2}^-$
28	2.044	1	$\frac{1}{2}^-,\frac{3}{2}^-$	1.304	0.109, 0.051		2.04	$\frac{1}{2}^-,\frac{3}{2}^-$
29	2.105 [e]	(3)	$(\frac{5}{2}^-,\frac{7}{2}^-)$	4.305	(0.260, 0.153)		2.10	$(\frac{3}{2}^+ + \frac{7}{2}^-)$
							2.15	$(\frac{1}{2}^+)$

TABLE II. *(Continued)*

Present study						Other studies		
Peak No.	E_x (MeV)	l_n	J^π	$d\sigma/d\Omega$ [a] (mb/sr)	Spectroscopic factor S_n	γ-ray [b] studies E_x (MeV)	Direct [c] reactions E_x (MeV)	J^π
						2.1747		
30	2.178	1	$\frac{1}{2}^-, \frac{3}{2}^-$	0.428	0.037, 0.018		2.18	$(\frac{3}{2}^+ + \frac{7}{2}^-)$
31	2.244	1	$\frac{1}{2}^-, \frac{3}{2}^-$	0.408	0.037, 0.017		2.24	$\frac{1}{2}^-, \frac{3}{2}^-$
32	2.273	(1)	$(\frac{1}{2}^-, \frac{3}{2}^-)$	0.098	(0.009, 0.004)		2.27	
							2.28	
33	2.311	1	$\frac{1}{2}^-, \frac{3}{2}^-$	1.601	0.147, 0.069		2.31	$\frac{1}{2}^-, \frac{3}{2}^-$
34	2.346	(3)	$(\frac{5}{2}^-, \frac{7}{2}^-)$	0.408	(0.024, 0.014)		2.35	
35	2.376	3	$\frac{5}{2}^-, \frac{7}{2}^-$	0.089	0.005, 0.003	2.3752		$(\frac{19}{2}^+)$

[a] Cross sections are at the diffraction maxima between 10° and 40° depending on l_n transfer as shown in Figs. 1 and 3.
[b] References 1, 11, and 12.
[c] References 1 and 4.
[d] A possible doublet.
[e] This is a possible triplet and the cross section of this unresolved group has largely an $l_n = 3$ transfer shape.

cates that the $l_n = 3$ ($J^\pi = \frac{5}{2}^-$ or $\frac{7}{2}^-$) state is by far the strongest component. The 0.526 MeV level may be a doublet as well and again it has an $l_n = 3$ angular distribution shape.

B. ^{126}Te$(t,d)^{127}$Te

In the ^{126}Te$(t,d)^{127}$Te reaction, four new levels, at 1.154, 1.427, 1.961, and 2.258 MeV, were observed in addition to those observed in the ^{126}Te$(d,p)^{127}$Te reactions.[5,6] However, the level at 1.154 MeV was observed in a γ-ray study.[13] On the basis of (t,d) angular distribution shapes, the spin and parity assignments of low energy levels in the ^{127}Te nucleus compare very well with those of other studies, but our assignments differ in a few cases with the earlier studies for levels above 1.0 MeV. These are discussed below.

The spin and parity of the 1.285 MeV level were assigned[1] as $\frac{5}{2}^+$. However, the present (t,d) angular distribution has an $l_n = 3$ transfer shape indicating $J^\pi = \frac{5}{2}^-$ or $\frac{7}{2}^-$. As shown in Fig. 4, the angular distribution of the 1.399 MeV level has a distinctive $l_n = 4$ transfer shape ($J^\pi = \frac{7}{2}^+$ or $\frac{9}{2}^+$). It was previously assigned[1] as a $\frac{1}{2}^+$ state. The 2.081, 2.188, and 2.227 MeV levels have $l_n = 0$ transfer angular distribution shapes, whereas the 2.081 level was previously assigned as $(\frac{7}{2}^-)$ and the levels at 2.188 and 2.227 MeV were previously assigned as $(\frac{3}{2}^-)$ states,[5] incompatible with the present study. The 2.119 MeV excitation group, a possible doublet $(\frac{3}{2}^- + \frac{7}{2}^-)$ according to the previous[5] assignment, shows instead an $l_n = 3$ (t,d) angular distribution shape. The spin and parity of the level at 2.299 MeV were previously assigned $\frac{3}{2}^-$ by Graue *et al.*[5] and $\frac{5}{2}^-$, $\frac{7}{2}^-$ ($l_n = 3$) by Cohen *et al.*[6] The present (t,d) angular distribution also shows an $l_n = 3$ transfer shape, supporting the assignment of Cohen *et al.*[6] It is interesting to note that the ^{125}Te and ^{127}Te nuclei seem to have a higher level density below 2.5 MeV excitation than those observed in ^{129}Te and ^{131}Te nuclei (see below).

C. ^{128}Te$(t,d)^{129}$Te

Table IV summarizes the results of the ^{128}Te$(t,d)^{129}$Te reaction. The deuteron spectra of this reaction are quite similar to the proton spectra obtained in the (d,p) reactions[7] leading to ^{129}Te. However, in the present study, five new levels were observed, at 1.155, 1.210, 1.435, 1.558, and 1.837 MeV. The spin and parity assignments of states in ^{129}Te, as shown in Table IV, compare very well with those of earlier studies. The previously known[14-16] $\frac{9}{2}^-$ level at 0.465 MeV was not populated in the present study. Seven levels, at 0.179, 1.155, 1.654, 1.837, 2.131, 2.314, and 2.491 MeV, show $l_n = 0$ angular distribution shapes and thus this nucleus, ^{129}Te, seems to have more $\frac{1}{2}^+$ states than any of the neighboring odd Te isotopes. The spectroscopic factors in column 6 of Table IV compare quite well with those obtained in

TABLE III. Levels observed in ^{127}Te.

	Present study					Other studies		
						γ-ray[b] studies	Direct[c] reactions	
Peak No.	E_x (MeV)	l_n	J^π	$d\sigma/d\Omega$[a] (mb/sr)	Spectroscopic factor S_n	E_x (MeV)	E_x (MeV)	J^π
1	0.0	2	$\frac{3}{2}^+$	5.297	0.353	0.0	0.0	$\frac{3}{2}^+$
2	0.060	0	$\frac{1}{2}^+$	3.009	0.257	0.0611	0.06	$\frac{1}{2}^+$
3	0.087	5	$\frac{11}{2}^-$	0.793	0.165	0.0883	0.09	$\frac{11}{2}^-$
						0.3407	0.34	$\frac{9}{2}^-$
							0.37	
						0.4730	0.47	$\frac{5}{2}^+$
4	0.503	2	$\frac{3}{2}^+,\frac{5}{2}^+$	0.290	0.020, 0.011	0.503	0.50	
							0.51	
5	0.632	0	$\frac{1}{2}^+$	0.400	0.040	0.6315	0.63	$(\frac{1}{2}^+)$
							0.64	$(\frac{1}{2}^+)$
6	0.688					0.6857	0.69	$\frac{7}{2}^+$
7	0.764	2	$\frac{3}{2}^+,\frac{5}{2}^+$	0.311	0.021, 0.012	0.764	0.76	$\frac{3}{2}^+,\frac{5}{2}^+$
8	0.784	2	$\frac{5}{2}^+$	1.680	0.066	0.7837	0.78	$\frac{5}{2}^+$
						0.7858		$(\frac{9}{2}^-)$
9	0.925	4	$\frac{7}{2}^+$	0.144	0.032	0.924	0.92	$\frac{7}{2}^+$
							0.98	
10	1.076	(1)	$(\frac{1}{2}^-,\frac{3}{2}^-)$	0.078	(0.005, 0.002)	1.078	1.08	$(\frac{5}{2}^+,\frac{9}{2}^+)$
11	1.137	2	$\frac{5}{2}^+$	0.273	0.011	1.142	1.14	$\frac{5}{2}^+$
12	1.154	(5)	$(\frac{9}{2}^-,\frac{11}{2}^-)$	0.032	(0.014, 0.006)	1.155		
							1.18	
13	1.285	3	$\frac{5}{2}^-,\frac{7}{2}^-$	0.159	0.010, 0.006	1.290	1.28	$\frac{5}{2}^+$
						1.324		
14	1.348						1.35	$\frac{1}{2}^-,\frac{3}{2}^-$
15	1.373	2	$\frac{3}{2}^+,\frac{5}{2}^+$	0.126	0.009, 0.005	1.378	1.37	
16	1.399	4	$\frac{7}{2}^+,\frac{9}{2}^+$	0.172	0.035, 0.018		1.40	$\frac{1}{2}^+$
17	1.427	2	$\frac{3}{2}^+,\frac{5}{2}^+$	0.027	0.002, 0.001			
18	1.546	2	$\frac{3}{2}^+,\frac{5}{2}^+$	0.287	0.020, 0.012		1.55	$\frac{3}{2}^+,\frac{5}{2}^+$
19	1.676	1	$\frac{1}{2}^-,\frac{3}{2}^-$	0.098	0.008, 0.004		1.68	$\frac{1}{2}^-,\frac{3}{2}^-$
20	1.750	2	$\frac{3}{2}^+,\frac{5}{2}^+$	0.067	0.005, 0.003		1.75	
21	1.801	3	$\frac{5}{2}^-,\frac{7}{2}^-$	0.156[d]	0.011, 0.007		1.80	
22	1.902	2	$\frac{3}{2}^+,\frac{5}{2}^+$	0.540	0.039, 0.022		1.90	$(\frac{3}{2}^+)$
23	1.941	(3)	$(\frac{5}{2}^-,\frac{7}{2}^-)$	0.048	(0.003, 0.002)		1.94	
24	1.961							
25	1.992	1	$\frac{1}{2}^-,\frac{3}{2}^-$	0.766	0.072, 0.034		1.99	$(\frac{3}{2}^-)$
26	2.009	3	$\frac{5}{2}^-,\frac{7}{2}^-$	3.095	0.187, 0.111		2.01	$(\frac{7}{2}^-)$
27	2.081	0	$\frac{1}{2}^+$	1.327	0.234		2.08	$(\frac{7}{2}^-)$
28	2.119	(3)	$(\frac{5}{2}^-,\frac{7}{2}^-)$	3.570	(0.214, 0.127)		2.12	$(\frac{3}{2}^- + \frac{7}{2}^-)$
29	2.150	3	$\frac{5}{2}^-,\frac{7}{2}^-$	0.577	0.035, 0.020		2.15	$(\frac{7}{2}^-)$

TABLE III. *(Continued)*

	Present study					Other studies		
Peak No.	E_x (MeV)	l_n	J^π	$d\sigma/d\Omega$ [a] (mb/sr)	Spectroscopic factor S_n	γ-ray [b] studies E_x (MeV)	Direct [c] reactions E_x (MeV)	J^π
30	2.188	0	$\frac{1}{2}^+$	2.490	0.465		2.19	$(\frac{3}{2}^-$
31	2.227	0	$\frac{1}{2}^+$	0.356	0.068		2.23	$(\frac{3}{2}^-)$
32	2.258	2	$\frac{3}{2}^+, \frac{5}{2}^+$	0.070	0.005, 0.003			
33	2.299	3	$\frac{5}{2}^-, \frac{7}{2}^-$	1.036	0.061, 0.036		2.30	$\frac{5}{2}^-, \frac{7}{2}^-$
34	2.344						2.34	
35	2.382						2.38	
36	2.451	(1)	$(\frac{1}{2}^-, \frac{3}{2}^-)$	1.250	(0.146, 0.069)		2.45	$\frac{1}{2}^-$
37	2.478						2.48	

[a] Cross sections are at the diffraction maxima between 10° and 40° depending on l_n transfer as shown in Figs. 2 and 4, unless otherwise stated.
[b] References 1 and 13.
[c] References 1 and 5.
[d] Cross section at $\theta_{c.m.} = 25.5°$.

the ^{128}Te$(d,p)^{129}$Te reaction study by Moore *et al.*[7] Of all the odd tellurium isotopes studied, least was known about the spins and parities of many levels observed[1] in ^{129}Te. In the present (t,d) study, the orbital angular momentum l_n could be assigned to many of those states in ^{129}Te unambiguously. However, because of the lack of J dependence in the (t,d) angular distribution shapes, the J^π values of states can only be assigned as $J^\pi = l_n \pm \frac{1}{2}$, as shown in column 4 of Table IV.

D. ^{130}Te$(t,d)^{131}$Te

The levels below 2.5 MeV in ^{131}Te populated in the present ^{130}Te$(t,d)^{131}$Te reaction are shown in Table V. These are also compared with the results obtained in other studies.[1,8,9,16,17] Column 6 of Table V shows the spectroscopic factors obtained from the present study. These compare very well with the results of Graue *et al.*[8] obtained in the ^{130}Te$(d,p)^{131}$Te reaction. The levels at 0.857, 1.274, 1.840, 1.865, and 2.145 MeV were not observed before, either in γ-ray studies or in other charged-particle reaction studies. The 0.944 and 2.069 MeV levels populated in the present study were only seen in decay studies[16,17] but not in previous direct reaction studies.[8,9] The spin and parity assignments of column 4 in Table V compare well with those of other studies (column 9). The 0.882 MeV state was assigned to be $\frac{3}{2}^-$ by Graue *et al.*[8] and $\frac{3}{2}^+$ by Blachot *et al.*[16] However, the (t,d) angular distribution of this state has an $l_n = 3$ angular distribution shape indicating a $\frac{5}{2}^-$ or $\frac{7}{2}^-$ assignment. The states at 1.471 and 1.786 MeV were previously interpreted[8] as $\frac{1}{2}^-$ or $\frac{3}{2}^-$ ($l_n = 1$), but their present (t,d) angular distributions favor $\frac{3}{2}^+$ or $\frac{5}{2}^+$ ($l_n = 2$) and $\frac{5}{2}^-$ or $\frac{7}{2}^-$ ($l_n = 3$) assignments, respectively. Several states such as those at 0.7769, 1.2676, and 1.6018 MeV and higher observed in γ-ray studies were not populated in the ^{130}Te$(t,d)^{131}$Te reaction. The 1.659 MeV level may be a doublet, but its angular distribution shape indicates that the major component comes from an $l_n = 2$ transfer.

V. SUMMARY AND CONCLUSIONS

As discussed earlier, the overall features of the deuteron spectra from the present ^{A}Te$(t,d)^{A+1}$Te ($A = 124$, 126, 128, and 130) reactions as shown in Fig. 1 are quite similar to those of proton spectra from the ^{A}Te$(d,p)^{A+1}$Te reaction studies of Refs. 2, 5, 7, and 8. However, in the present (t,d) study, several new levels were populated which were not seen in the previous (d,p) studies. The majority of these levels have orbital angular momentum $l_n \geq 2$ which is, in fact, expected since in the present work, both the incident triton momentum and the momentum mismatch between the incident and outgoing channels are larger than those of the previous (d,p) reaction studies.[2,5,7,8] DWBA fits to the ^{A}Te$(t,d)^{A+1}$Te angular distributions, using optical model parameters set $T1D1$ of Table I, compare quite well with the experiment. The

TABLE IV. Levels observed in ^{129}Te.

	Present study					Other studies		
Peak No.	E_x (MeV)	l_n	J^π	$d\sigma/d\Omega$ [a] (mb/sr)	Spectroscopic factor S_n	γ-ray [b] studies E_x (MeV)	Direct [c] reactions E_x (MeV)	J^π
1	0.0	2	$\frac{3}{2}^+$	4.758	0.317	0.0	0.0	$\frac{3}{2}^+$
2	0.106	5	$\frac{11}{2}^-$	0.621	0.238	0.1055	0.11	$\frac{11}{2}^-$
3	0.179	0	$\frac{1}{2}^+$	2.119	0.197	0.1808	0.18	$\frac{1}{2}^+$
							0.24	
							0.37	
						0.4649	0.46	$\frac{9}{2}^-$
4	0.542	2	$\frac{3}{2}^+,\frac{5}{2}^+$	0.056	0.004, 0.002	0.5447	0.54	$(\frac{5}{2}^+,\frac{7}{2}^+)$
5	0.635	2	$\frac{3}{2}^+,\frac{5}{2}^+$	0.111	0.008, 0.004	0.634	0.64	$(\frac{3}{2}^+,\frac{5}{2}^+)$
							0.73	
6	0.763	3	$\frac{5}{2}^-,\frac{7}{2}^-$	0.391	0.026, 0.015	0.760	0.76	$(\frac{7}{2}^-,\frac{9}{2}^-)$
							0.80	
7	0.814	(4)	$(\frac{7}{2}^+,\frac{9}{2}^+)$	0.045	(0.010, 0.005)	0.8128		$(\frac{5}{2}^+,\frac{7}{2}^+)$
8	0.878	3	$\frac{5}{2}^-,\frac{7}{2}^-$	0.091	0.006, 0.003		0.87	
9	0.967	2	$\frac{5}{2}^+$	0.780	0.032	0.9664	0.97	$\frac{5}{2}^+$
							1.11	
10	1.155	0	$\frac{1}{2}^+$	0.016	0.002			
11	1.210	4	$\frac{7}{2}^+,\frac{9}{2}^+$	0.059	0.015, 0.006			
						1.228	1.23	
12	1.284	2	$\frac{3}{2}^+,\frac{5}{2}^+$	0.210	0.015, 0.009	1.281	1.28	
13	1.306	4	$\frac{7}{2}^+,\frac{9}{2}^+$	0.109	0.022, 0.011		1.31	
						1.318		
							1.40	
14	1.435	(2)	$(\frac{3}{2}^+,\frac{5}{2}^+)$	0.040	(0.003, 0.002)			
15	1.487	4	$\frac{7}{2}^+,\frac{9}{2}^+$	0.007	0.002, 0.001		1.49	
16	1.558	1	$\frac{1}{2}^-,\frac{3}{2}^-$	0.034	0.003, 0.001			
						1.599		
						1.633		
17	1.654	0	$\frac{1}{2}^+$	0.178 [d]	0.035	1.655	1.65	
						1.727		$(\frac{9}{2}^+)$
18	1.753	2	$\frac{3}{2}^+,\frac{5}{2}^+$	0.251	0.019, 0.010	1.753	1.75	
19	1.776	(2)	$(\frac{3}{2}^+,\frac{5}{2}^+)$	0.056	(0.004, 0.002)		1.78	
20	1.837	(0)	$(\frac{1}{2}^+)$	0.018	(0.003)			
						1.843		$(\frac{7}{2}^+,\frac{9}{2}^+)$
21	1.869	3	$\frac{5}{2}^-,\frac{7}{2}^-$	0.113	0.007, 0.004	1.871	1.87	
22	2.040	1	$\frac{1}{2}^-,\frac{3}{2}^-$	0.270	0.029, 0.014	2.043	2.04	
23	2.071	3	$\frac{5}{2}^-,\frac{7}{2}^-$	0.289	0.018, 0.010	2.070	2.07	
						2.085		

TABLE IV. *(Continued)*

Peak No.	E_x (MeV)	l_n	J^π	$d\sigma/d\Omega$ [a] (mb/sr)	Spectroscopic factor S_n	γ-ray [b] studies E_x (MeV)	Other studies Direct [c] reactions E_x (MeV)	J^π
24	2.108	3	$\frac{5}{2}^-, \frac{7}{2}^-$	3.572	0.216, 0.128	2.113	2.11	$(\frac{7}{2})^-$
25	2.131	(0)	$(\frac{1}{2}^+)$	0.190	(0.040)	2.133	2.13	
26	2.221	3	$\frac{5}{2}^-, \frac{7}{2}^-$	5.998	0.360, 0.214		2.22	$(\frac{7}{2})^-$
27	2.261	1	$\frac{1}{2}^-, \frac{3}{2}^-$	0.300	0.037, 0.017		2.26	$(\frac{3}{2})^-$
28	2.314	(0)	$(\frac{1}{2}^+)$	0.110	(0.026)		2.31	
29	2.360	1	$\frac{1}{2}^-, \frac{3}{2}^-$	2.600	0.337, 0.159		2.36	$(\frac{3}{2})^-$
30	2.379	1	$\frac{1}{2}^-, \frac{3}{2}^-$	1.700	0.223, 0.105		2.38	$(\frac{3}{2})^-$
31	2.491	0	$\frac{1}{2}^+$	0.116	0.032		2.49	

[a] Cross sections are at the diffraction maxima between 10° and 40° depending on l_n transfer as shown in Figs. 2 and 5, unless otherwise stated.
[b] References 1, 14, and 15.
[c] References 1 and 7.
[d] Cross section at $\theta_{c.m.} = 15.3°$.

spectroscopic factors obtained from these calculations also compare very well with those obtained in (d,p) studies,[5,7,8] except in the ^{124}Te$(t,d)^{125}$Te reaction. In this case the present values are ~25% lower than those of the (d,p) reaction.[2] However, these present values compare better with the spectroscopic factors obtained in (t,d) and (d,p) reactions on other tellurium isotopes. In the ^{124}Te$(d,p)^{125}$Te reaction at much lower beam energies, Graue *et al.*[2] showed that the magnitudes of the predicted cross sections might change ~15% simply by using a second set of deuteron optical model parameters. Graue *et al.*[2] also used lower cutoffs of 4.1–6.6 fm in the radial integral in the DWBA calculations depending on l_n transfer. It was claimed that such radial cutoffs only changed the forward angle cross sections. Their spectroscopic factors were obtained by comparing the large angle cross sections and were not affected by using such lower cutoffs.[2] In the present ^{A}Te$(t,d)^{A+1}$Te reaction calculations, only one set of deuteron optical model parameters and no radial cutoff were used. Thus it is difficult to pinpoint the reason for the difference in the spectroscopic factors in these two studies leading to the ^{125}Te nucleus.

As mentioned earlier, the ^{126}Te$(^3$He$,\alpha)^{125}$Te reaction[4] is the only previous study which has higher momentum mismatch than the (t,d) and (d,p) reactions. As expected, the 0.144 MeV $\frac{11}{2}^-$ (highest l value) is the strongest state in the ^{126}Te$(^3$He$,\alpha)^{125}$Te spectra. This state is fairly strong in (t,d), but relatively weak in (d,p) compared to the strongly excited ground and first excited states. The 1.322 and 1.364 levels were observed only in the (t,d) and $(^3$He$,\alpha)$ reactions. The $(^3$He$,\alpha)$ study had a resolution of ~45 keV and it could not separate the other higher l-value states from their neighbors, such as the 0.642 ($l=4$) and 0.671 ($l=2$) MeV states. Comparing the ^{125}Te spectra obtained in the $(^3$He$,\alpha)$, (t,d), and (d,p) reactions, it appears that the relative population of different states in the (t,d) spectrum is more similar to that observed for the (d,p) reaction than for the $(^3$He$,\alpha)$ reaction. This may be due to the fact that the $(^3$He$,\alpha)$ reaction is a neutron pickup reaction, whereas the (t,d) and (d,p) are neutron transfer reactions.

The level schemes of $^{123-131}_{52}$Te$_{71-79}$ isotopes from the present and previous studies are shown and compared in Fig. 7. For the sake of completeness the level scheme of ^{123}Te from Refs. 1 and 11 is included in this figure. In these tellurium isotopes with neutron numbers 71–79 between the closed neutron shells at $N=50$ and 82, most of the levels are thought to arise mainly from the single quasiparticle $(3s_{1/2}, 2d_{3/2}, 1h_{11/2})$, pairing vibration and quasiparticle-phonon coupling such as $2_1^+ \otimes s_{1/2}$, $2_1^+ \otimes d_{3/2}$, and $2_1^+ \otimes h_{11/2}$. However, as discussed in Sec. I, levels due to three-quasiparticles, five-quasiparticle cluster, and strong coupling schemes are also known to exist in these nuclei. The low-

TABLE V. Levels observed in ^{131}Te.

	Present study					Other studies		
Peak No.	E_x (MeV)	l_n	J^π	$d\sigma/d\Omega$ [a] (mb/sr)	Spectroscopic factor S_n	γ-ray [b] studies E_x (MeV)	Direct [c] reactions E_x (MeV)	J^π
1	0.0	2	$\frac{3}{2}^+$	3.617	0.243	0.0	0.0	$\frac{3}{2}^+$
2	0.183	5	$\frac{11}{2}^-$	0.446	0.161	0.1822	0.18	$\frac{11}{2}^-$
3	0.297	0	$\frac{1}{2}^+$	1.584	0.161	0.2957	0.30	$\frac{1}{2}^+$
4	0.643	2	$\frac{5}{2}^+$	0.053	0.002	0.6423	0.64	$\frac{5}{2}^+$
						0.7769		
5	0.857	0	$\frac{1}{2}^+$	0.016	0.002			
6	0.882	3	$\frac{5}{2}^-, \frac{7}{2}^-$	0.182	0.012, 0.007		0.88	$\frac{3}{2}^{(\pm)}$
7	0.944	4	$\frac{7}{2}^+$	0.028	0.006	0.9435		$\frac{7}{2}^+$
						1.0362		$\frac{7}{2}^-$
8	1.043 [d]	0	$\frac{1}{2}^+$	0.050	0.007	1.0508	1.04	$\frac{1}{2}^+$
9	1.209	2	$\frac{5}{2}^+$	0.486	0.021	1.2074	1.21	$\frac{5}{2}^+$
						1.2676		$\frac{7}{2}^+$
10	1.274	2	$\frac{3}{2}^+, \frac{5}{2}^+$	0.024 [e]	0.002, 0.001			
11	1.400	5	$\frac{9}{2}^-, \frac{11}{2}^-$	0.019	0.007, 0.005	1.3989	1.40	
12	1.471	2	$\frac{3}{2}^+, \frac{5}{2}^+$	0.155	0.012, 0.007	1.4703	1.47	$(\frac{1}{2}^-, \frac{3}{2}^-)$
						1.6018		
13	1.659 [d]	2	$\frac{3}{2}^+, \frac{5}{2}^+$	0.071	0.005, 0.003		1.66	
						1.6698		
14	1.722	2	$\frac{3}{2}^+, \frac{5}{2}^+$	0.075	0.006, 0.003	1.7220	1.72	
15	1.786	3	$\frac{5}{2}^-, \frac{7}{2}^-$	0.320	0.020, 0.012		1.79	$\frac{1}{2}^-, \frac{3}{2}^-$
16	1.840	3	$\frac{5}{2}^-, \frac{7}{2}^-$	0.023	0.014, 0.008			
17	1.865	0	$\frac{1}{2}^+$	0.043	0.009			
						1.8766		
18	2.014	(1)	$(\frac{1}{2}^-, \frac{3}{2}^-)$	0.110	(0.013, 0.006)	2.017	2.01	$\frac{1}{2}^-, \frac{3}{2}^-$
19	2.069	(4)	$(\frac{7}{2}^+, \frac{9}{2}^+)$	0.015	(0.003, 0.001)	2.0671		$\frac{5}{2}^+, \frac{9}{2}^+$
20	2.092	(1)	$(\frac{1}{2}^-, \frac{3}{2}^-)$	0.085	(0.011, 0.005)		2.09	
21	2.145							
						2.1799		
						2.2262		
22	2.278	3	$\frac{7}{2}^-$	11.090	0.401		2.28	$\frac{7}{2}^-$
23	2.329	3	$\frac{5}{2}^-, \frac{7}{2}^-$	0.337	0.020, 0.012	2.3350	2.33	
24	2.372	(3)	$(\frac{5}{2}^-, \frac{7}{2}^-)$	0.480	(0.029, 0.017)		2.37	
						2.3987		$(\frac{5}{2}^+, \frac{7}{2}^+)$
						2.4966		$(\frac{5}{2}^+, \frac{7}{2}^+)$

[a] Cross sections are at the deffraction maxima between 10° and 40° depending on l_n transfer as shown in Figs. 2 and 6, unless otherwise stated.
[b] References 1, 16, and 17.
[c] References 1, 8, and 9.
[d] A possible doublet.
[e] Cross section at $\theta_{c.m.} = 20.4°$.

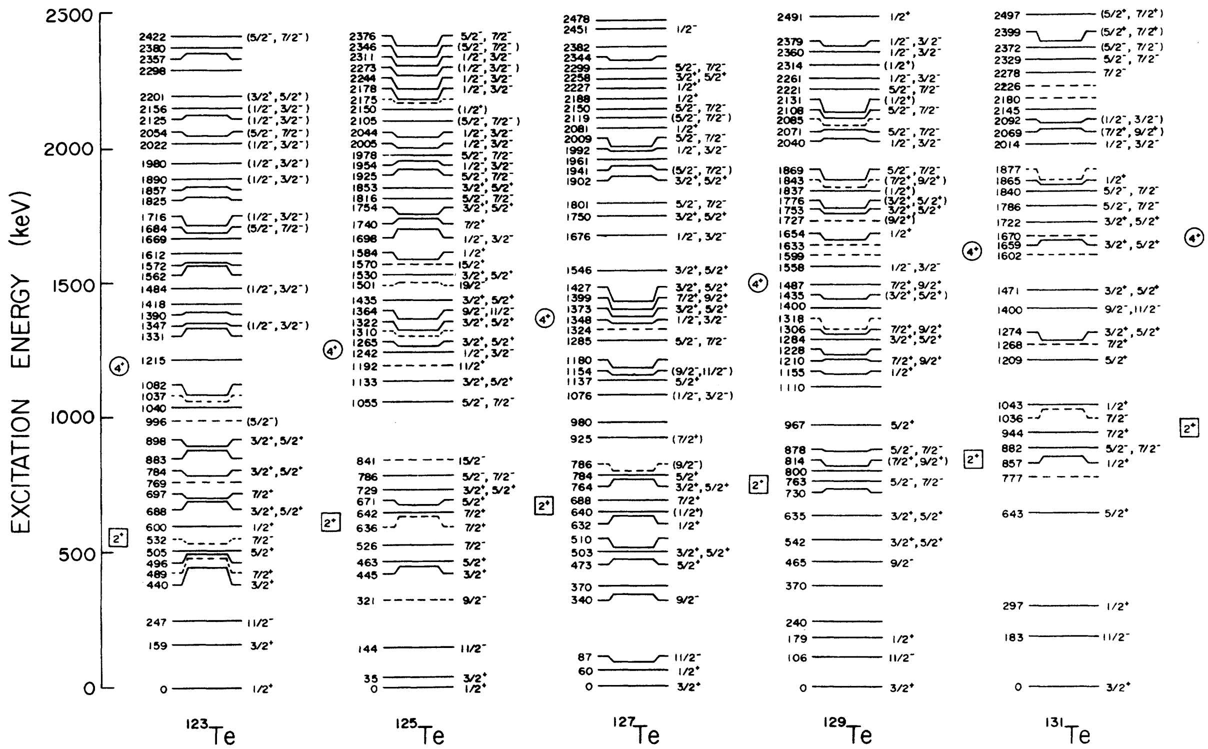

FIG. 7. A comparison between the level schemes of ^{123}Te, ^{125}Te, ^{127}Te, ^{129}Te, and ^{131}Te nuclei below 2.5 MeV excitation. The levels shown by the dashed lines are observed only in γ-ray studies, but not in direct reactions. The level scheme of ^{123}Te is from Refs. 1 and 11. The positions of the 2_1^+ and 4_1^+ levels in neighboring even-even tellurium nuclei are also shown.

est $\frac{1}{2}^+$, $\frac{3}{2}^+$, and $\frac{11}{2}^-$ states in these nuclei are identified as pure single-quasiparticle states. The other positive parity states may be due to any of the schemes mentioned above. It is difficult to identify a configuration for each of these levels, especially since all of the above models had some success in explaining some of the broad features of their level schemes and also since mixing between all such configurations must surely exist. For example, the excitation energies of these states increase with the increase in neutron number and in a quasiparticle-phonon coupling model, this can be traced to the increasing 2_1^+ excitation energies in the corresponding even-even Te nuclei.

In ^{125}Te the $\frac{9}{2}^-$ level at 0.321 MeV has been definitely identified as a three-quasiparticle state.[10,11,16,19] It is thus tempting to identify the $\frac{9}{2}^-$ level at 0.340 MeV in ^{127}Te and 0.465 MeV in ^{129}Te as the corresponding three-quasiparticle states in those nuclei. These levels are not observed in the present (t,d) or the previous (d,p) reactions and these reactions are not expected to populate such states with complicated configurations. However, the $\frac{9}{2}^-$ level at 0.340 MeV in ^{127}Te was observed in the ^{128}Te$(p,d)^{127}$Te reaction[1] and the $\frac{9}{2}^-$ level at 0.465 MeV in ^{129}Te was observed in the ^{130}Te$(p,d)^{129}$Te and ^{130}Te$(d,t)^{129}$Te reaction.[1] This would suggest a simpler than three-quasiparticle configuration for these $\frac{9}{2}^-$ states. A similar $\frac{9}{2}^-$ level has not been observed in ^{131}Te. The first $\frac{9}{2}^-$ level in this nucleus appears at 1.400 MeV. Due to the lack of J dependence in the Te(t,d) reactions, it was not possible to identify the J value of a state from the present study. Thus it can not add any more information to what is already known about the detailed confirmation of states. High spin positive and negative parity states ($J^\pi > \frac{9}{2}^+$ and $\frac{11}{2}^-$) have only been observed in ^{125}Te in a ^{124}Sn$(\alpha, 3n\gamma)$ reaction study.[10] Such $(\alpha, xn\gamma)$ or (HI, $xn\gamma$) reactions to populate high spin states in other odd Te nuclei would be interesting.

ACKNOWLEDGMENTS

The authors would like to thank A. Larabee and S. Angelo for their assistance during the experiments. This work was supported by the Natural Sciences and Engineering Research Council (NSERC) of Canada.

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