and

$$F(ll'I_fI)=[(2I+1)(2l+1)(2l'+1)]^{1/2} \times W(IIl l'KI_f)(l-1l'1|KO)$$

are numerical coefficients obtained from published tables. $\cos(\Delta_L-\Delta_{L'})$ is a factor due to the differing effect of the Coulomb barrier on waves of different angular momenta. For alpha particles emitted well below the height of the Coulomb barrier, Seed and French[24] have shown that

$$\Delta_{L+2}-\Delta_L=\tan^{-1}\left[\frac{n}{L+2}\right]+\tan^{-1}\left[\frac{n}{L}\right], \quad (8)$$

where

$$n=2Ze^2/\hbar v,$$

v being the alpha-particle velocity.

It can be shown that

$$\frac{g_L}{g_{L'}}=\frac{\langle I\|H_1(L)\|I_i\rangle}{\langle I\|H_1(L')\|I_i\rangle}\cos(\Delta_L-\Delta_{L'}). \quad (9)$$

[24] J. Seed and A. P. French, Phys. Rev. 88, 1007 (1952).

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Decay of ^{124}Sb to ^{124}Te†

P. H. Stelson
Oak Ridge National Laboratory, Oak Ridge, Tennessee
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The γ rays from 60-day ^{124}Sb have been measured with a Ge γ-ray detector. γ-γ coincidence and correlation measurements were made with a Ge detector and a NaI scintillation detector. β-γ coincidences were made using a Ge detector and anthracene scintillation detector. The Ge detector was placed in a large NaI annulus detector to provide both anticoincidence Compton-suppressed spectra and high-resolution γ-ray pair spectra. A total of 25 γ rays were observed. A level scheme is proposed which contains 13 levels. Angular-correlation measurements (a) confirm a spin-4 assignment to the 1247.6-keV state and (b) show that the spin of the 1325.0-keV state is 2 and that the 722.5-keV γ ray to the first 2^+ state has a mixture $\delta\equiv(E^2/M1)^{1/2}=3.4\pm0.6$. Two levels at 1956.5 and 2038 keV have properties which are consistent with a three-phonon collective-state interpretation.

I. INTRODUCTION

Many investigations have been made of the rather complicated decay of 60-day ^{124}Sb. It was partly because it had been so well studied that we chose this activity to test the power of Ge γ-ray detectors to yield new information on decay schemes. In addition to the straightforward high-resolution singles spectra obtained with a Ge detector, other more complex arrangements were used. Gamma-gamma coincidence and correlation measurements were made with one Ge detector and one NaI scintillation crystal. Beta-gamma coincidences were made with the Ge γ-ray detector and an anthracene scintillation detector. In another arrangement, the Ge detector was put inside a large NaI annular detector which was operated in anticoincidence to suppress pulses from unwanted Compton events produced in the Ge detector. Finally, the Ge detector was put inside the NaI annulus and the annulus was operated as two optically isolated halves. By requiring coincident 511-keV pulses from each half of the annulus one had a very effective high-resolution pair spectrometer for detection of the higher-energy γ rays.

The ^{124}Te nucleus exhibits a "vibrational" type of level structure. The known spin of 3 for ^{124}Sb and the large available decay energy suggest that there might be an appreciable population of the postulated 2^+, 3^+, and 4^+ members of a three-phonon quintet of collective states. It is expected that one of the most sensitive "signatures" for this type of state will be the peculiar intensities of the γ rays resulting from the decay of these states to lower states in analogy to the well-known peculiar decay of the second 2^+ state in vibrational-type nuclei. We hoped to find this type of information for states in ^{124}Te. Yoshizawa[1] has pointed out that there is some evidence for states in other vibrational nuclei which have γ-ray decay characteristics that are consistent with the concept of three-phonon-type states.

There has been a disagreement on the value of δ $[\delta=\pm(E2/M1)^{1/2}]$ for the decay of the second 2^+ state (1325 keV) to the first 2^+ state in ^{124}Te. Lindquist and Marklund,[2] Paul,[3] and Raghavan *et al.*[4] found that $\delta\approx1$. This value of δ is smaller than those usually found for nuclei similar to ^{124}Te. On the other hand, Glaubman and Oberholtzer[5] found $\delta=+4.1\pm0.6$ and Dorikens-

† Research sponsored by the U. S. Atomic Energy Commission under contract with the Union Carbide Corporation.

[1] Y. Yoshizawa, Phys. Letters 2, 261 (1962).
[2] T. Lingqvist and I. Marklund, Nucl. Phys. 4, 189 (1957).
[3] H. Paul, Phys. Rev. 121, 1175 (1961).
[4] R. S. Raghavan, Z. W. Grabowski, and R. M. Steffen, Phys. Rev. 139, 1 (1965).

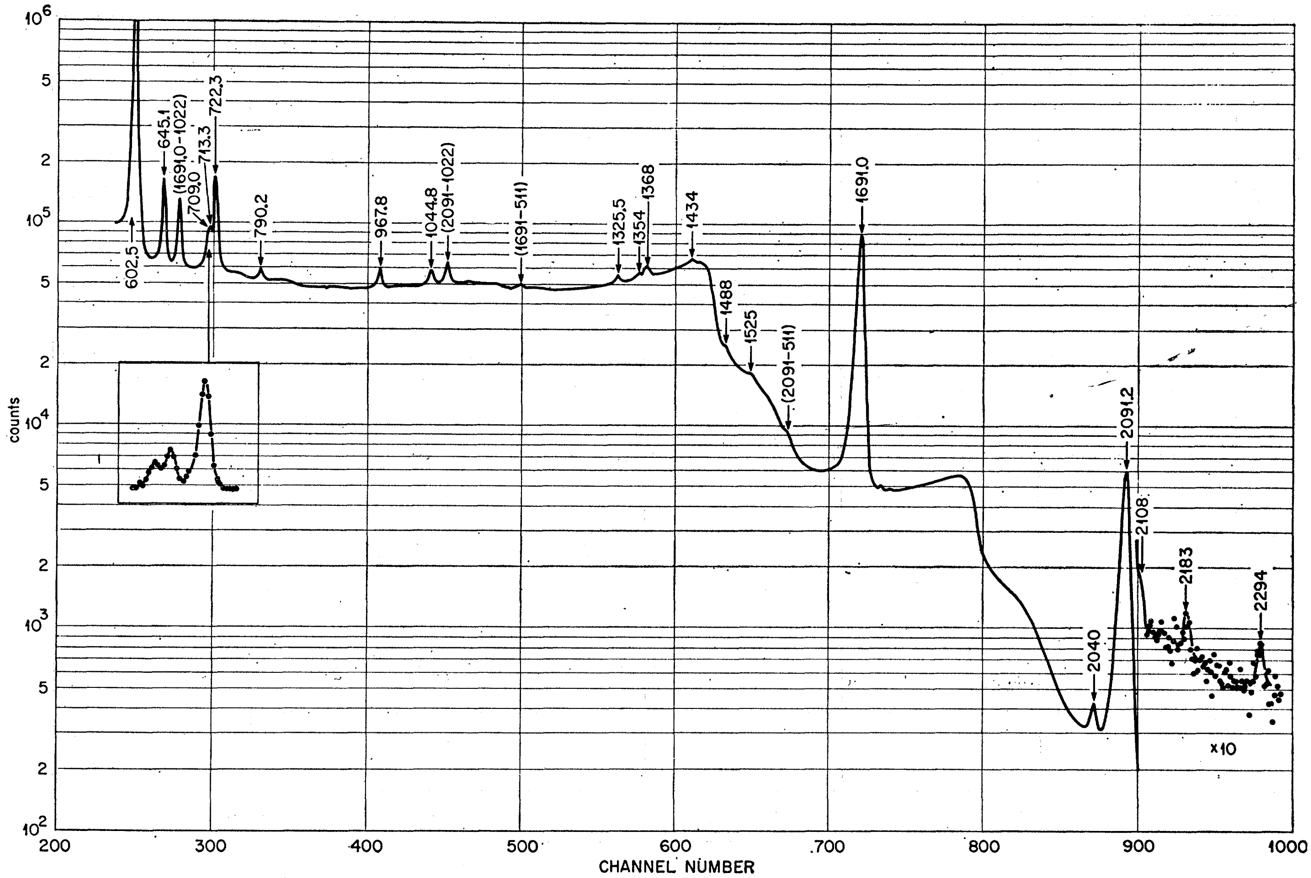

FIG. 1. A representative singles γ-ray spectrum for a ^{124}Sb source taken with a Ge detector.

Vanpraet *et al.*[6] obtained $\delta^2 \simeq 6$. With the improved resolution of the Ge detector, the γ-γ angular correlation measurement becomes much cleaner and we hoped to resolve this difference.

With the improved energy resolution, it was also possible to look at the γ-γ angular correlation from the decay of the second excited state at 1247 keV. Glaubman and Oberholtzer[5] have measured this correlation and find a result which is consistent with a 4^+ assignment. However, Dorikens-Vanpraet *et al.*[6] have also measured this angular correlation and they found the unexpected result that the spin of the second excited state is 3^+. This result is in strong disagreement with the extensively studied systematic behavior of level sequences in vibrational-type nuclei.

II. EXPERIMENTAL METHOD AND RESULTS

The Ge detector used for the measurements was built at ORNL.[7] It was cylindrical in shape with an area of

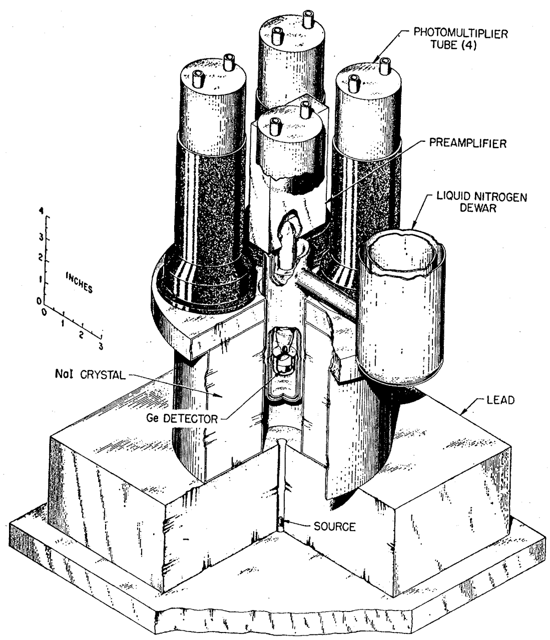

FIG. 2. A schematic diagram of the experimental arrangement used to operate the Ge detector in a NaI mantle.

[5] M. J. Glaubman and J. D. Oberholtzer, Phys. Rev. **135**, 1313 (1964).

[6] L. Dorikens-Vanpraet, J. Demuyrk, and M. Dorikens, Nucl. Phys. **73**, 539 (1965).

[7] Fabricated by R. J. Fox of the Instrumentation and Controls Division.

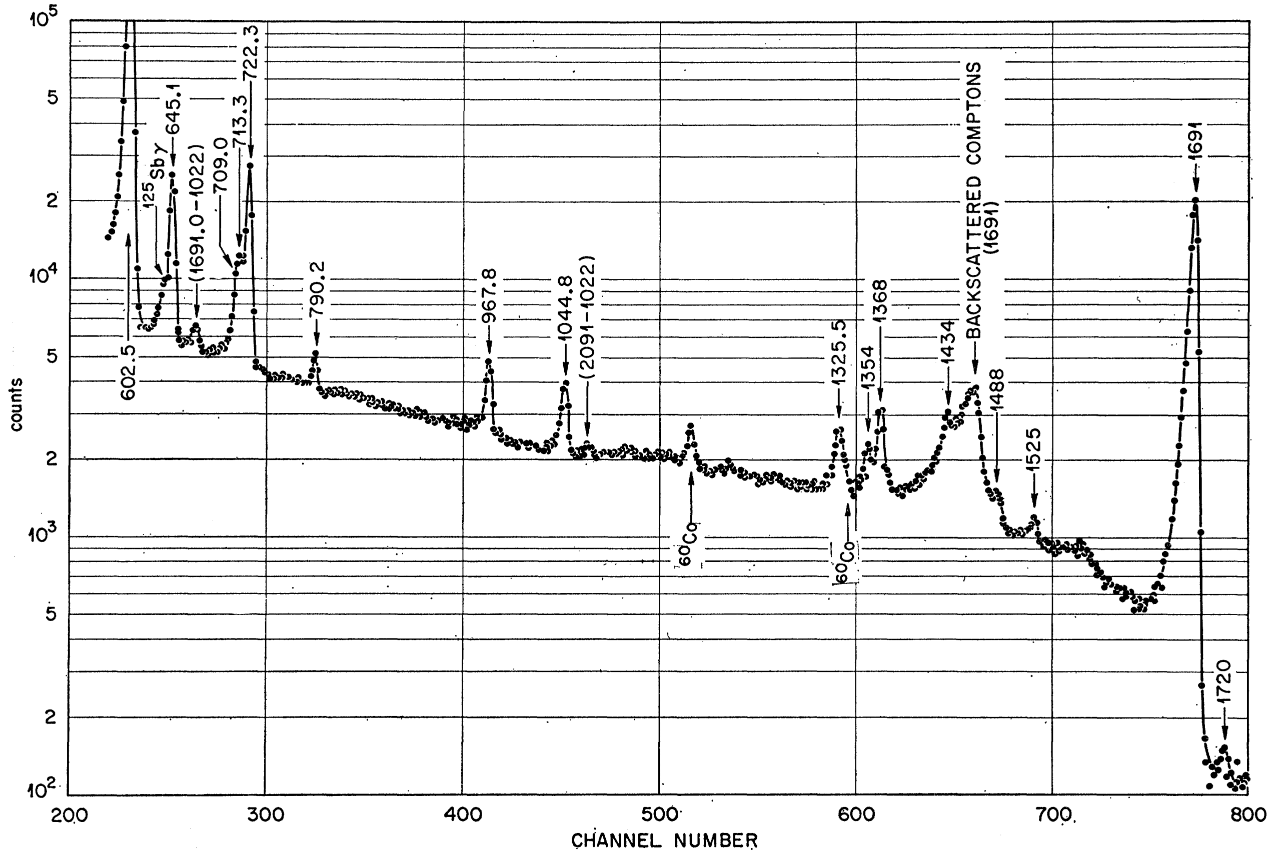

FIG. 3. A spectrum for ^{124}Sb taken with an anticoincidence NaI mantle to suppress Compton background.

2.7 cm^2 and a depth of about 8 mm. A representative singles γ-ray spectrum taken on a 1024-channel pulse-height analyzer is shown in Fig. 1. The peaks are identified in the figure. The absolute energies of the γ rays were determined by taking combination spectra of ^{124}Sb and other radioactive sources with accurately known γ rays. The procedure followed was the same as that described by Robinson *et al.*[8]

When the energy region 700–725 keV was expanded, it was clear that at least three peaks were present. An expanded spectrum of this region, taken with the better resolution recently made possible by the use of a field-effect preamplifier, is shown in the insert in Fig. 1. The three γ-ray peaks at 709, 713, and 722 keV are clearly resolved.

A particularly troublesome difficulty with the Ge spectrum for ^{124}Sb is the strong intensity of the 1691-keV γ ray. The high Compton level resulting from this γ ray obscures the weak lower-energy γ rays. To improve the situation, the Ge detector was operated in an anticoincidence NaI mantle. The experimental arrangement is shown in Fig. 2. The NaI annulus had an o.d. of 8 in., and i.d. of 2 in. and a length of 6 in. A representative Ge spectrum taken with the anticoincidence mantle is shown in Fig. 3. One sees that the weak γ-ray peaks are now considerably more prominent. For example, the 1325.5-keV peak in Fig. 1 is only about 10% of the background level, whereas in Fig. 3 it is about equal to the background level. The Compton level is not uniformly suppressed. Those Compton events which result in a back-scattered or forward-scattered γ ray do not interact with the mantle. Another difference in the spectra taken with and without the mantle is that those peaks which result from pair production with double or single escape of the annihilation radiation are largely suppressed in the spectrum taken with the mantle. The elimination of these escape peaks is a convenient additional check on the correct assignment of these peaks.

The anticoincidence mantle was built so that it could be operated as two optically isolated halves. An efficient-pair spectrometer was realized by putting a single-channel window on the 511-keV peak in each half of the annulus and then requiring a coincidence to gate on the multichannel analyzer which was connected to the Ge detector system. A representative-pair spectrum is shown in Fig. 4. The peaks are identified in the figure.

[8] R. L. Robinson, P. H. Stelson, F. K. McGowan, J. L. C. Ford, Jr., and W. T. Milner, Nucl. Phys. 74, 281 (1965).

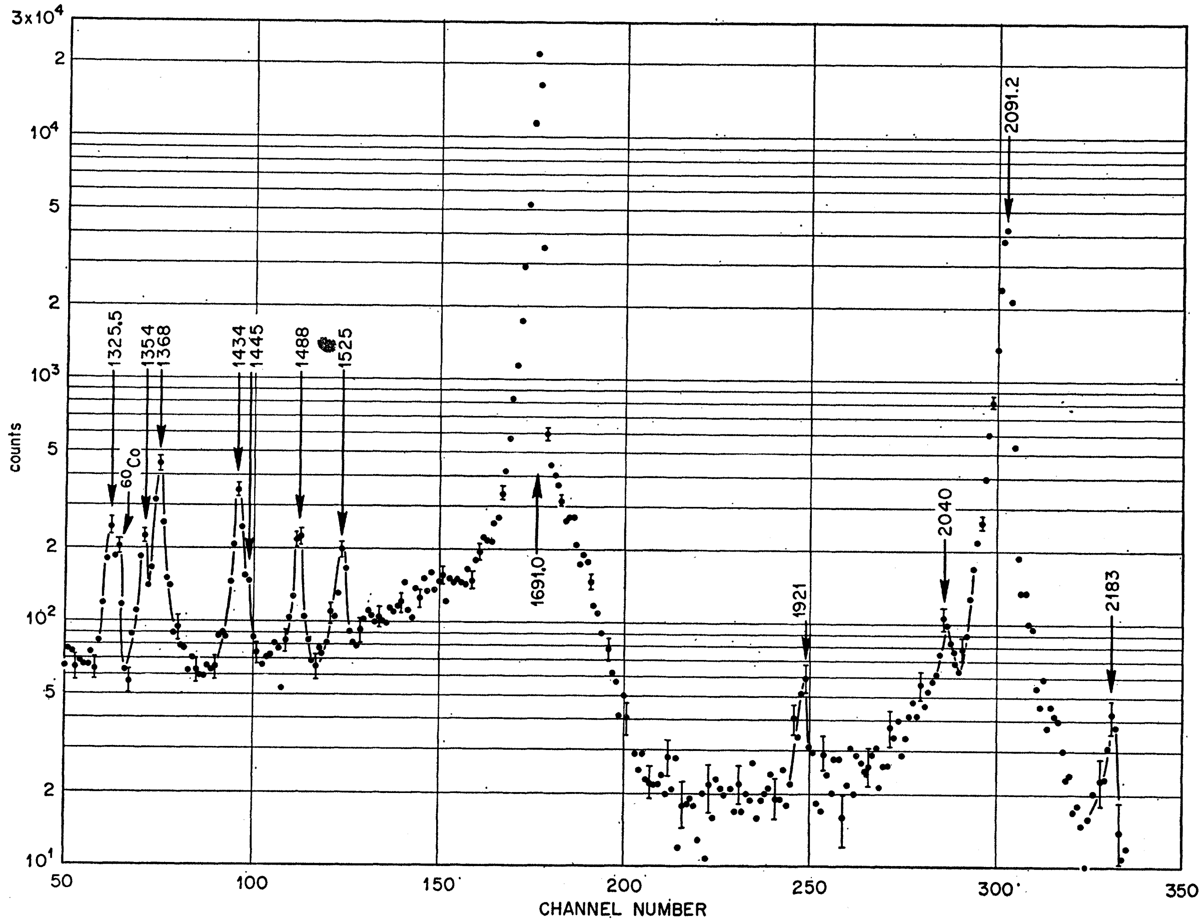

FIG. 4. A representative spectrum for a ^{124}Sb source which results from using the Ge detector and the split NaI annulus as a γ-ray pair spectrometer.

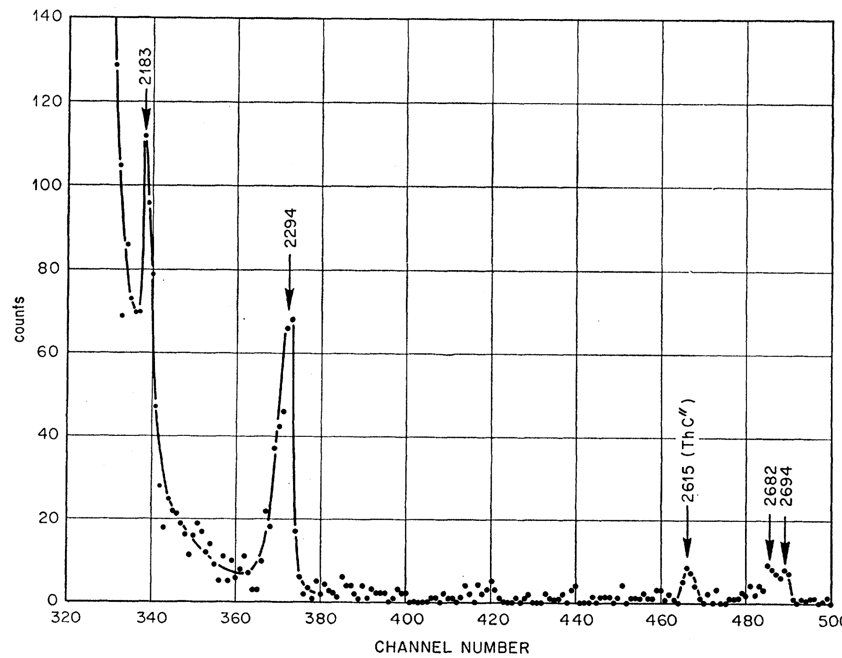

FIG. 5. ^{124}Sb γ-ray pair spectrum at higher energies.

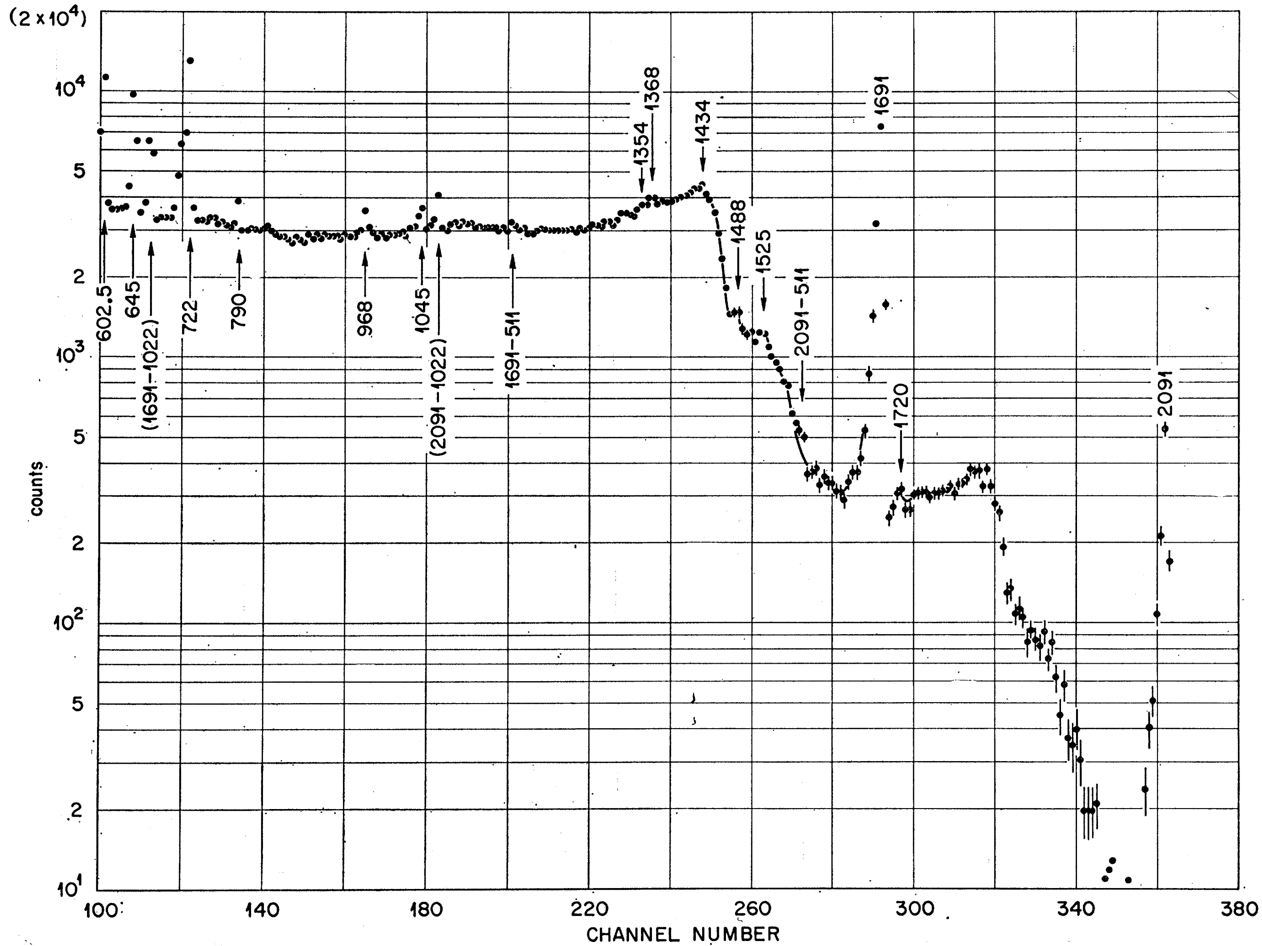

FIG. 6. A NaI-Ge coincidence spectrum. The Ge detector spectrum is shown when a window is placed on the 602.5-keV γ-ray peak in the NaI spectrum.

Because the pair spectrum has a single peak for each γ ray there is an increased sensitivity for discovering weak γ rays in the presence of strong γ rays. For example, the 1445-keV γ ray was not identified until pair spectra were taken. In addition, the relative intensities of the γ rays are more accurately determined.

The very strong peaks due to the 1691- and 2091-keV γ rays are superimposed on somewhat broader peaks which extend to higher energies than the sharp peak. We believe that these higher-energy pulses result from small-angle Compton scattering of the annihilation γ rays in the Ge detector. The degraded γ rays still have enough energy to give a pulse within the window of the NaI crystal. The Compton scattering deposits some additional energy in the Ge detector. We have found that we can alter the shape of this broad weak peak by changing the position and width of the single-channel windows set on the NaI crystal.

In contrast to the results reported by other workers who used NaI crystals, we found that the γ rays with energies higher than the 2091-keV γ ray are extremely weak.[9] A pair spectrum of this high-energy region is shown in Fig. 5. This spectrum is the result of several long runs amounting to a total time of several days.

The energies of the γ rays observed in the decay of ^{124}Sb are given in Table I together with their relative intensities. The relative efficiency of our Ge detector was calibrated by taking the reliable relative intensities of the 602.5- and 1691-keV γ rays deduced from NaI work. In addition, a ^{24}Na source was also used to calibrate both singles spectra efficiency and the relative efficiency of the pair spectrometer. In general, the relative intensities of γ rays determined by full-energy peaks and by pair peaks were in good agreement.

Gamma-ray spectra of the ^{124}Sb source were taken at various times for about a one-year period in order to follow the decay of the source. Several high-energy γ rays with energies of 1575, 1508, 1906, and 1998 keV (all fairly weak) were observed to decay with a faster half-life. We are not able to assign these γ rays to an-

[9] See Nuclear Data Sheets, edited by K. Way *et al.* (U. S. Government Printing & Publishing Office, Washington, D. C.).

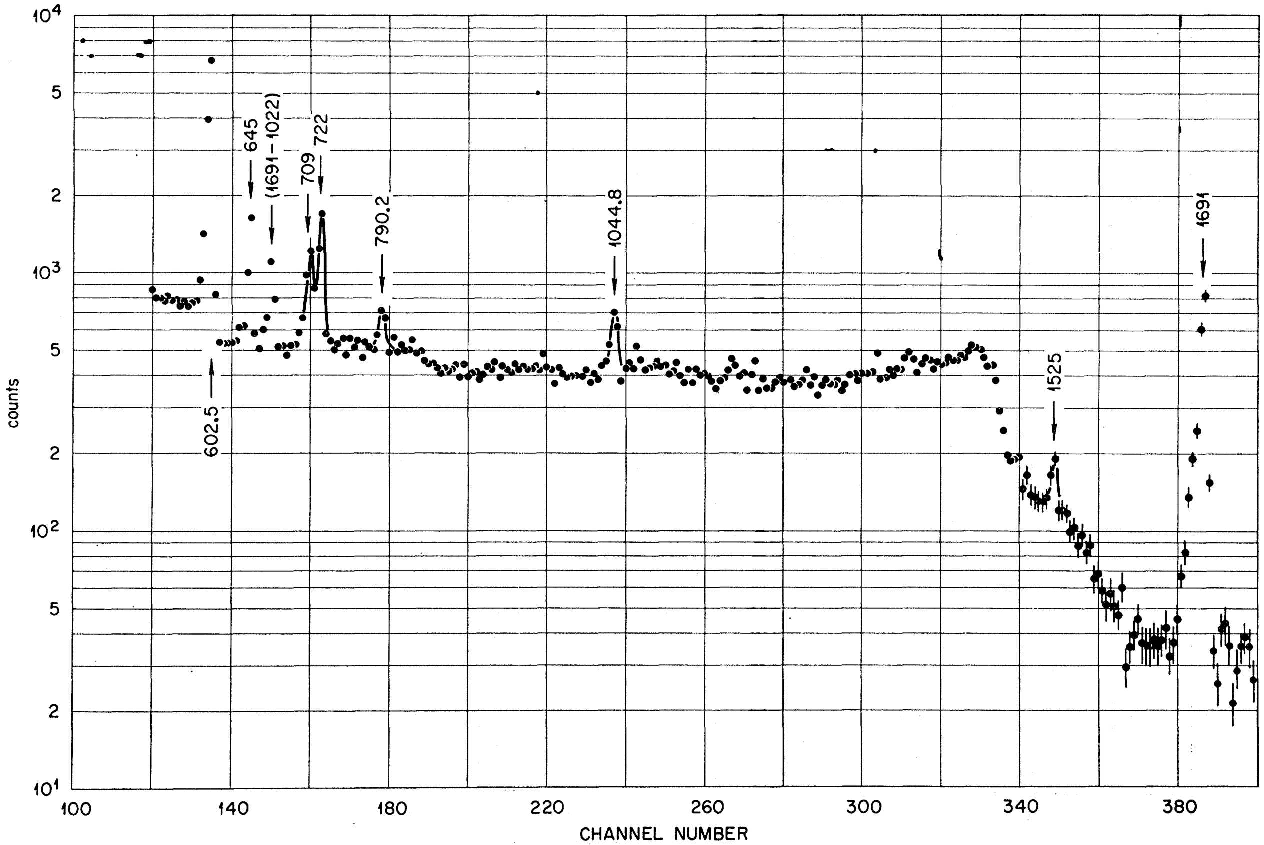

FIG. 7. A NaI-Ge coincidence spectrum. The Ge detector spectrum is shown when a window is placed on the 645-keV γ-ray peak in the NaI spectrum.

other known activity. After a year, the source also exhibited lower-energy γ rays from ^{125}Sb which has a longer half-life and which would have been produced at the time the source was made by double-neutron capture.

Several γ-γ coincidence spectra were taken with two Ge detectors. These spectra had very poor statistical accuracy. However, we did observe that when a narrow window was put on the 645-keV γ ray, which results from the decay of the second-excited state, there were coincident γ rays with energies $\sim$603, $\sim$709, and $\sim$1044 keV. When the narrow window was put on the 722-keV γ ray we observed coincident peaks at $\sim$603, $\sim$713, $\sim$968, and $\sim$1368 keV.

The 602.5-keV γ ray in ^{124}Sb spectrum is sufficiently different in energy from the other γ rays that it is feasible to use the poor resolution but high efficiency of a 3-in.×3-in. NaI crystal to make γ-γ angular correlation measurements for this γ ray. A window was set on the 602.5-keV peak detected by the NaI spectrometer and the coincident spectrum from the Ge detector was recorded on a multichannel analyzer. The correlation was measured at $\theta=180°$, 140°, and 90°. The observed coefficients of the Legendre polynomials $P_2(\cos\theta)$ and $P_4(\cos\theta)$ are given in Table II.

TABLE I. A summary of the observed γ rays in the decay of ^{124}Sb.

E_γ (keV)	Relative intensity
602.5±0.3	100
645.1±0.3	8.5 ±1
709.0±0.5	1.8 ±0.3
713.3±0.5	2.8 ±0.5
722.3±0.3	12.5 ±1
790.2±0.5	0.8 ±0.1
967.8±0.3	2.3 ±0.3
1044.8±0.3	2.0 ±0.3
1325.5±0.5	1.6 ±0.3
1354 ±1.0	1.2 ±0.2
1368 ±1.0	3.0 ±0.4
1434 ±1.0	1.4 ±0.2
1445 ±1.0	0.3 ±0.1
1488 ±1.0	0.8 ±0.2
1525 ±1.0	0.5 ±0.1
1691 ±0.5	50
1720 ±1.0	0.15 ±0.04
1921 ±2	0.07 ±0.02
2040 ±2	0.05 ±0.01
2091.2±0.5	6.0 ±0.5
2108 ±1.0	0.03 ±0.01
2183 ±2	0.030±0.007
2294 ±2	0.030±0.007
2682 ±3	~0.002
2694 ±3	~0.002

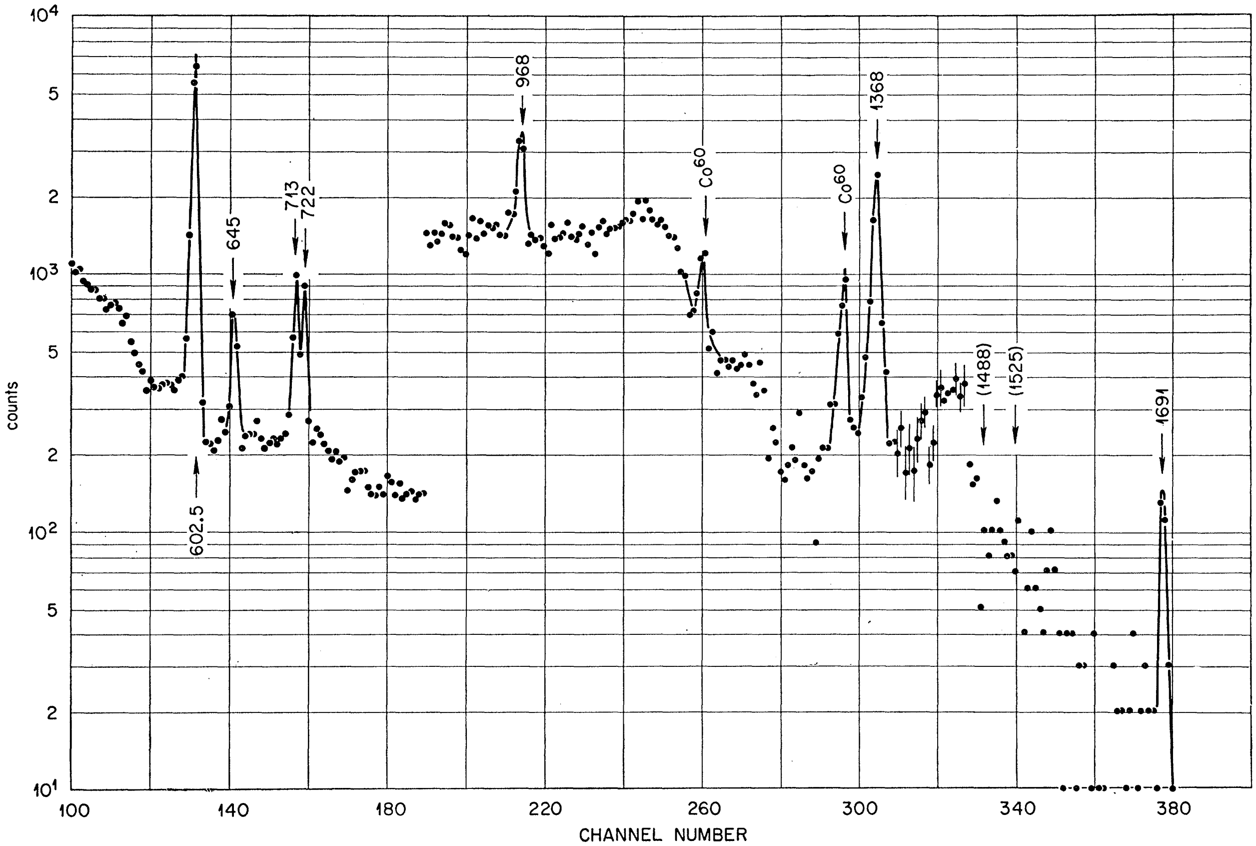

FIG. 8. A NaI-Ge coincidence spectrum. The Ge detector spectrum is shown when a window is placed on the 722-, 713-, and 709-keV composite peak in the NaI spectrum. Note that the 1488- and 1525-keV peaks are not present in this spectrum.

Although the poor energy resolution of the NaI spectrometer is an obvious drawback, nevertheless the high statistical accuracy of (NaI)-(Ge) coincidence spectra made these spectra extremely useful in establishing the decay scheme. Three such coincidence spectra are shown in Figs. 6, 7, and 8. The coincident Ge spectra are shown which result when a window was placed on the full-energy peaks at (a) 602 keV, (b) 645 keV, and (c) 722 keV in the NaI detector. The detailed interpretations of these spectra are given below.

Finally, it proved useful to make β-γ coincidence measurements. A Ge detector spectrum is shown in Fig. 9 which results when a window was placed on the β spectrum in an anthracene scintillation detector which accepted pulses of 480- to 950-keV energy. Since the β-ray endpoints for the strongly populated states at 2293 and 2693.5 keV are 622 and 222 keV, the γ rays resulting from the decay of these states were strongly suppressed in the β-γ coincidence spectrum. The relative intensities of other γ rays in the coincidence spectrum indicated whether the γ rays originated from β-ray population of levels above or below an excitation of about 2.3 MeV in ^{124}Te.

TABLE II. The observed coefficients of the Legendre polynomials $P_2(\cos\theta)$ and $P_4(\cos\theta)$ for the angular correlations of γ-ray cascades given in column 1.

Cascade (keV)	A_2	A_4
645.1–602.5	$+0.12\ \pm0.04$	$0\ \ \pm0.05$
722.3–602.5	$+0.14\ \pm0.03$	$+0.26\pm0.04$
1691.0–602.5	-0.099 ± 0.026	$+0.03\pm0.03$

III. DISCUSSION

A. Level Scheme

The basic problem is to devise a level scheme for ^{124}Te which uniquely accounts for the γ rays given in Table I. Our proposed level scheme is given in Fig. 10. The strongly populated levels at 602.5, 1247.6, 1325.0, 2293, and 2693.5 keV are essentially identical to those previously proposed.[9] These levels account for 12 of the observed γ rays.

1956.5-keV State

The 1354-keV γ ray is in coincidence with the 602.5-keV γ ray but not with the 645- or 722-keV γ rays. The

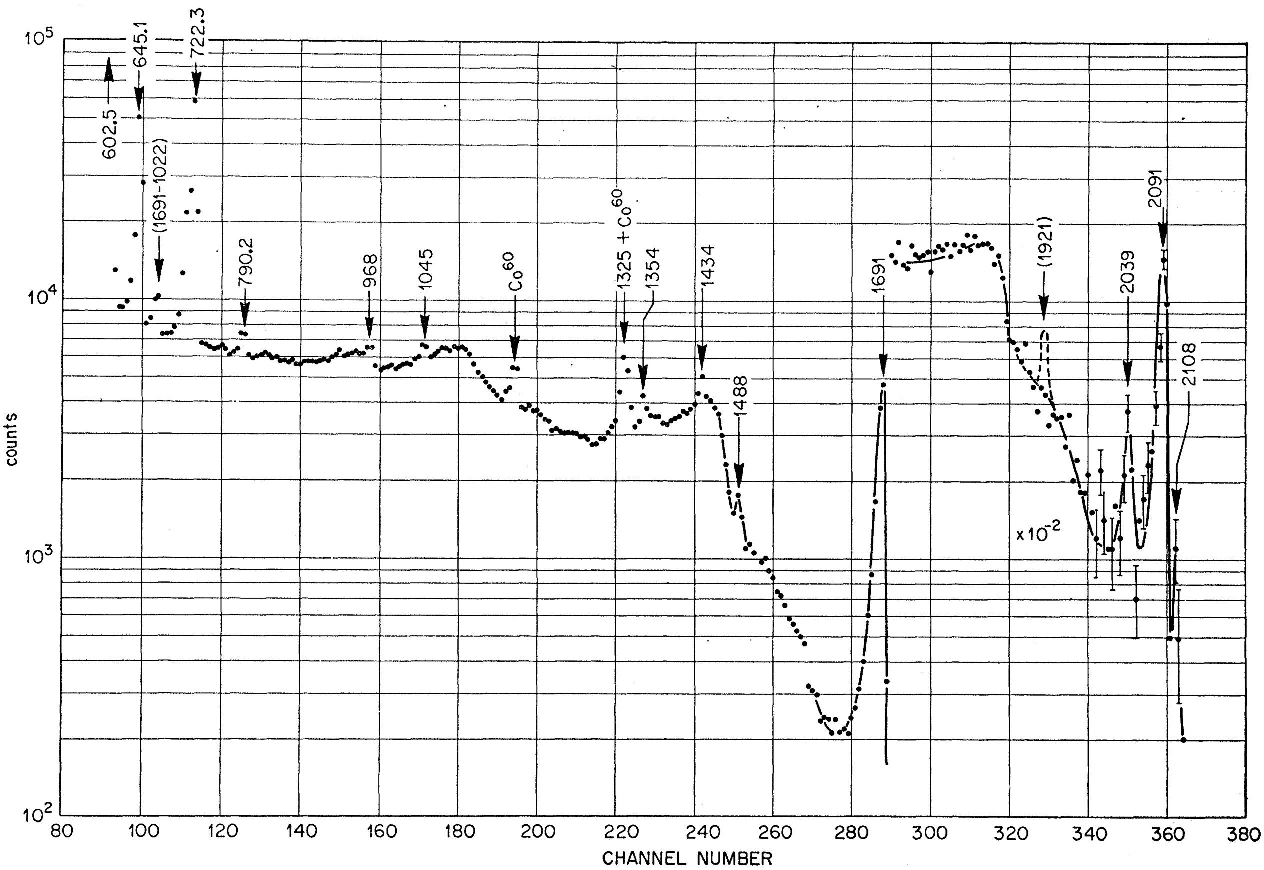

FIG. 9. A β-γ coincidence spectrum. The Ge spectrum is shown when a window is placed on the anthracene-scintillation spectrum which accepted pulses of 480- to 950-keV energy. A dashed peak is shown which is the expected intensity of a 1921-keV γ ray if this peak resulted from the direct population of a state at 1921 keV.

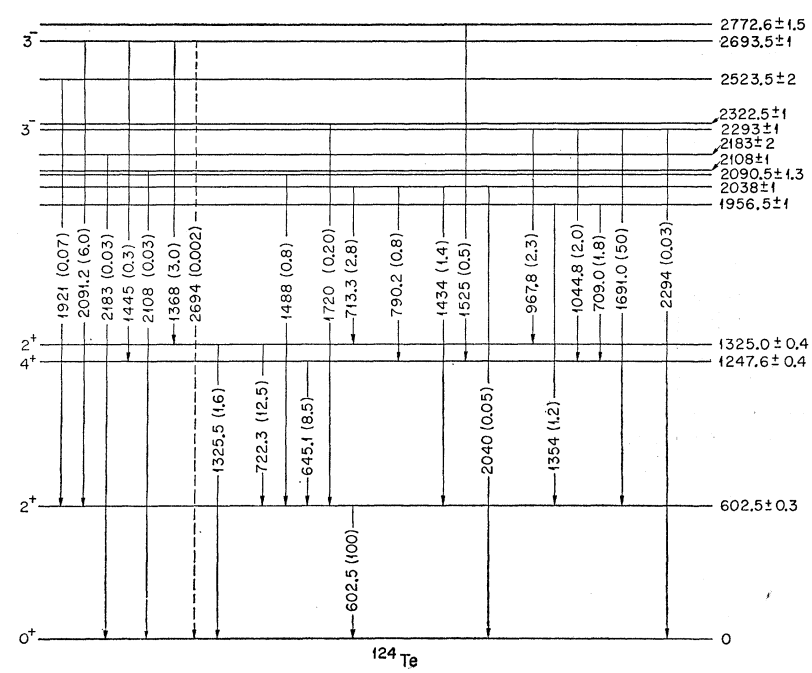

FIG. 10. Proposed level scheme for the decay of ^{124}Sb to states in ^{124}Te. The γ-ray intensities are given in parentheses after the γ-ray energies. The intensity of the 602.5-keV γ ray is taken as 100.

TABLE III. Upper limits on the intensities of γ rays which were not observed but which might be present according to the proposed level scheme for ^{124}Te. The first column identifies the transition, the second column gives the expected γ-ray energy and the third column gives the upper limit for the intensity of the γ ray.

Transition	E_γ (keV)	Intensity limit
1956.5 → 0	1956.5	<0.02
1956.5 → 1325.0	631.5	<0.4
2090.5 → 0	2090.5	None
2090.5 → 1247.6	842.9	<0.04
2090.5 → 1325.0	765.5	<0.10
2108 → 602.5	1505.5	<0.05
2183 → 602.5	1580.5	<0.10
2322.5 → 0	2322.5	<0.002
2322.5 → 1247.6	1074.9	<0.10
2322.5 → 1325.0	997.5	<0.10
2523.5 → 0	2523.5	<0.001
2523.5 → 1247.6	1275.9	<0.20
2523.5 → 1325.0	1198.5	<0.10
2772.6 → 0	2772.6	None
2772.6 → 602.5	2170.1	<0.006
2772.6 → 1325.0	1447.6	<0.3

fact that the 1354-keV γ ray is present in appreciable strength in the β-γ coincidence spectrum implies that it does not originate from a state greater than 2.3 MeV in excitation energy. These facts all point to the existence of a state at 1956.5 keV which decays by a 1354-keV γ ray to the 602.5-keV state. The newly identified 709.0-keV γ ray then has a very natural assignment as the γ ray between the 1956.5-keV state and the 1247.6-keV state. This assignment is further strengthened by the fact that the 709.0-keV γ ray is in coincidence with the 645-keV γ ray. Two other possible γ rays originating from the state at 1956.5 keV, viz. the crossover 1956.5-keV γ ray and the 631.5-keV γ ray (1956.5-keV→1325.0-keV transition) are not seen. Upper limits for the intensities of these γ rays are given in Table III.

2038-keV States

The evidence for a new state at 2038 keV is very strong. The existence of such a state accounts for four of the observed γ rays with energies of 713.3, 790.2, 1434, and 2040 keV. The assignment of these γ rays to a state at 2038 keV is further strengthened by the following observations: (a) All four γ rays are relatively prominent in the β-γ coincidence spectrum which implies that they originate from a state below 2.3-MeV excitation energy, (b) the 790.2-keV γ ray is in coincidence with the 645-keV γ ray, (c) the 713.3-keV γ ray is in coincidence with the 722.3-keV γ ray, and (d) the 713.3-, 790.2-, and 1434-keV γ rays are in coincidence with the 602.5-keV γ ray.

2090.5-keV State

The following facts were observed for the 1488-keV γ ray: It is rather prominent in the β-γ coincidence spectrum and hence must originate from a state below 2.3-MeV excitation energy. It is in coincidence with the 602.5-keV γ ray and not in coincidence with the 645- and 722-keV γ rays. These facts force one to postulate the existence of a state at 2090.5 keV. Upper limits for other possible γ rays which might arise from the decay of this state are given in Table III.

2108-keV State

A weak γ ray with an energy of 2108 keV is observed in the decay of ^{124}Sb. There is some evidence that this γ ray is present in the β-γ coincidence spectrum and thus suggests that the γ ray originates from the decay of a state at 2108 keV. There is no additional corroborative evidence for the existence of a state at 2108 keV.

2322.5-keV State

The weak γ ray with an energy of 1720 keV also appears in the coincidence spectrum with the window on the 602.5-keV γ ray. This evidence suggests that there is an excited state at 2322.5 keV. There is no additional evidence for the existence of this state.

2183-keV State

A weak 2183-keV γ ray is definitely observed in the decay of ^{124}Sb. However, it is not very clear from the measurements whether this γ ray originates from a state at 2183 keV or from a state at 2785.5 keV (2183+602.5 keV). The coincidence spectra, which should decide between these two possibilities, do not have enough counts to draw meaningful conclusions. We have tentatively assigned the γ ray to a state at 2183 keV.

2523.5-keV State

The observed 1921-keV γ ray could result from the direct population of a state at 1921 keV or from a state at 2523.5 keV with the 1921-keV γ ray resulting from the decay of this state to the 602.5-keV state. The 1921-keV γ ray was not observed in the β-γ coincidence spectrum. A dashed peak in Fig. 9 shows the expected intensity of the 1921-keV γ ray resulted from the population of a state at 1921 keV. We therefore draw the conclusion that the 1921-keV γ ray results from the population of a state at 2523.5 keV. Limits for the intensities of other possible γ rays resulting from the decay of this are given in Table III.

2772.6-keV State

The following observations were made on the 1525-keV γ ray: This γ ray is in coincidence with the 645-keV γ ray. The γ ray is missing in the β-γ coincidence spectrum which implies that it comes from the decay of a state above 2.3 MeV. We therefore conclude that there must be a state at 2772.6 MeV which decays by the 1525-keV γ ray to the 1247.6-keV state.

In summary, we believe that the evidence is quite

TABLE IV. Relative intensities of direct population by β decay of the different states in ^{124}Te. The last column gives the log ft values.

Excited state (keV)	$E(\beta^-)$ (keV)	Percentage population	Log ft
602.5	2313	20	10.2
1247.6	1668	4.3	10.5
1325.0	1591	5.9	10.2
1956.5	959	3.0	9.6
2038	878	4.9	9.3
2090.5	825	0.8	10.0
2108	807	0.03	11.4
2183	733	0.03	11.2
2293	622	53	7.8
2322.5	592	0.20	10.3
2523.5	392	0.07	10.2
2693.5	222	8.6	7.0
2772.6	143	0.5	7.6

convincing for the existence of states in ^{124}Te at 602.5, 1247.6, 1325.0, 1956.5, 2038, 2293, and 2693.5 keV. This is fairly conclusive evidence for states at 2090.5, 2523.5, and 2772.6 keV. The evidence is least satisfactory for the weakly populated states proposed at 2108, 2183, and 2322.5 keV.

B. Angular Correlations

645.1–602.5-keV Cascade

The values for A_2 and A_4 expected for a

$$4 \xrightarrow{E2} 2 \xrightarrow{E2} 2 \rightarrow 0$$

cascade are +0.102 and +0.009. Our values agree with these theoretical values. They also agree with the experimental values obtained by Glaubman and Oberholtzer,[5] but they disagree with the experimental results of Dorikens-Vanpraet *et al.*[6] We conclude that the state at 1247.6 keV is a 4^+ state and not a 3^+ state as given by Dorikens-Vanpraet *et al.*[6]

722.3–602.5-keV Cascade

The experimental results for this angular correlation are shown in Fig. 11. The three experimental ratios are shown together with the expected theoretical values for the sequence

$$2 \xrightarrow{E2+M1} 2 \xrightarrow{E2} 0$$

as a function of $\delta \equiv (E2/M1)^{1/2}$. The experimental results are consistent with $\delta = 3.4 \pm 0.6$. Our result is in good agreement with the results of Glaubman and Oberholtzer[4] who obtained $\delta + 4.1 \pm 0.6$. As can be seen from the Fig. 11, our result definitely disagrees with those previous results which obtained $\delta = +1$.[1–3] Although apparently not realized by Paul,[3] his experimental result can be fitted either by $\delta = +1$ or $\delta = +4$ and hence,[10]

[10] This conclusion was confirmed by private communication from R. M. Steffen.

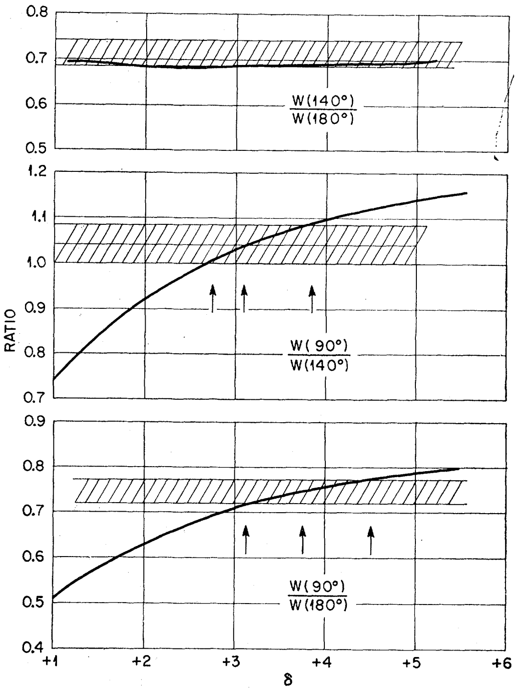

FIG. 11. Experimental results for the 722.3–602.5-keV cascade angular correlation. The solid curves show the theoretical intensity ratios for different values of $\delta \equiv (E2/M1)^{1/2}$ for the sequence

$$2 \xrightarrow{E2+M1} 2 \xrightarrow{E2} 0.$$

his result is not actually in confict with the result $\delta \sim +4$.

1691.0–602.5-keV Cascade

Our results are not as accurate as those of previous measurements on this cascade. The present results agree to within the errors with the previously obtained values for A_2 and A_4.

C. Log ft Values

From the observed γ-ray intensities, it is possible to obtain the partial half-lives for β decay of the 3^- state in ^{124}Sb to the different excited states in ^{124}Te. This information is summarized in Table IV.

D. Gamma-Ray Transition Rates

The only transition rate which has been measured for ^{124}Te is the $E2$ transition rate from the first 2^+ state to the ground state. The Coulomb excitation result shows that this $E2$ transition is enhanced by a factor of 30. From the present experimental results it is possible to deduce that the ratio $B(E2)_{2'\rightarrow 2}/B(E2)_{2'\rightarrow 0}$ for the second 2^+ state is 150 ± 30. This large value is a striking example of the well-known rule for the $E2$ decay rates from the second 2^+ state of "vibrational" nuclei.

A curious feature of the level scheme for ^{124}Te is that there is good evidence for the existence of 3^- states at 2293 and 2693.5 keV. The $E3$ transition rates to the ground state are not yet known. However, direct interaction experiments[11] have established that the collective 3^- state in ^{126}Te is at 2395 keV and that the $E3$ enhancement is approximately 20. No other 3^- state was found in ^{126}Te below 3 MeV. One can conclude that another possible 3^- state below 3 MeV in ^{126}Te must have a cross section at least 5 times smaller than that for excitation of the 2395-keV state.

If we therefore assume that the collective 3^- state is the lower one at 2293 keV and take the $E3$ transition rate to the ground state to be similar to that for ^{126}Te [$B(E3)_{3^-\to 0}=2\times10^{-74}$ cm$^6e^2$], then we can obtain approximate values for the $E1$ transition rates (neglecting possible small $M2$ admixtures) to the first and second 2^+ states and to the first 4^+ state. The values are: $B(E1)_{3^-\to 2^+}=8\times10^{-30}$ cm$^2e^2$, $B(E1)_{3^-\to 2^{+\prime}}=2\times10^{-30}$ cm$^2e^2$, and $B(E1)_{3^-\to 4^+}=1.4\times10^{-30}$ cm$^2e^2$. These values are 10^3 to 10^4 times smaller than the single-particle $B(E1)$ value.

Possibly the most intriguing feature to emerge from the present measurements is the peculiar decay characteristics of the 2038- and 1956.5-keV states. For example, the 2038-keV state decays to both the first and second 2^+ states and although the available energy is a factor of two less for decay to the second 2^+ state, the observed intensity for this transition is twice as large as that to the first 2^+ state. The strong energy dependence of γ-ray transitions implies a much larger reduced transition probability for the 2038- to 1325-keV transition than for the 2038- to 602.5-keV transition. Since the ^{124}Sb state is known to be 3^-, the observed $\log ft$ values for the population of the 2038- and 1956.5-keV states indicate that the spins and parity of these states are 1^+, 2^+, 3^+, 4^+, or 5^+. Furthermore, one would expect three-phonon states to have about 2-MeV excitation energy. Therefore, the energies, parity, and possible spins of these two states are consistent with what one would expect for the 2^+, 3^+, or 4^+ members of a three-phonon quintet. The relatively large reduced transition strengths between the 2038-keV state and the 1247.6-keV (4^+) and the 1325-keV (2^+) states compared to that to the first 2^+ state is the characteristic feature that one expects for a three-phonon state. Similarly, the 1956.5-keV state decays preferentially to the 1247.6-keV state.

The available evidence on the properties of the two states at 2038 and 1956.5 keV suggests that they have the characteristics of three-phonon states. However, it is clear that angular-correlation measurements on the decay γ rays made with Ge detectors would be very desirable in order to find out multipolarity mixtures of the γ rays and the spins of the states.

[11] G. C. Pramila, R. Middleton, T. Tamura, and G. R. Satchler, Nucl. Phys. **61**, 448 (1965).

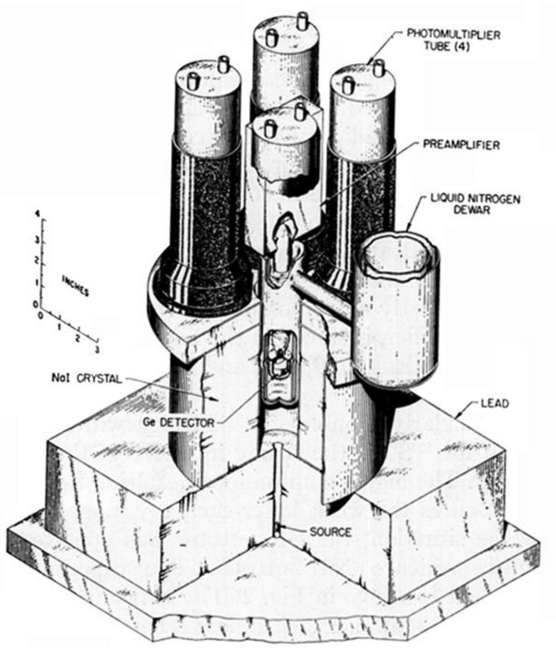

FIG. 2. A schematic diagram of the experimental arrangement used to operate the Ge detector in a NaI mantle.