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Decay of mass-separated ^{78}Ga to levels in even-even ^{78}Ge

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The decay of mass-separated ^{78}Ga produced in the thermal neutron fission of ^{235}U was studied and a decay scheme was deduced from results of γ-singles and coincidence measurements. The ^{78}Ga half-life was determined to be 5.49 ± 0.25 s and 45 γ transitions were placed in a level scheme for ^{78}Ge including 19 excited states up to 5078 keV. Observation of a level at 1644 keV with a probable J^π of 3^+ completes a level structure which is in good agreement up to 2 MeV with a dynamic deformation calculation.

[RADIOACTIVITY ^{78}Ge [from ^{235}U(n,f)]; measured $T_{1/2}$, E_γ, I_γ, $\gamma\gamma$-coin, Ge(Li) detectors; ^{78}Ga deduced levels, J, π, logft, Q_β. Mass-separated ^{78}Ga activity.]

I. INTRODUCTION

The only information in the literature on the decay scheme of ^{78}Ga is the work of Aleklett *et al.*[1] A half-life of 5.09 s was given along with a rudimentary decay scheme, but detailed information on γ energies and intensities was not presented. The level scheme was used primarily for determining Q_β for the decay using β-γ coincidence measurements. The Q_β was deduced to be 8.14 ± 0.16 MeV.

The only light-ion reaction available for the study of ^{78}Ge is ^{76}Ge$(t,p)^{78}$Ge. Experiments with tritons of 15 and 17 MeV have been carried out recently by Mateja *et al.*[2] and Ardouin *et al.*[3] The stable even-even Ge isotopes have recently been studied using the (t,p) reaction[4-6] and an extensive set of references on earlier work has been given by Lebrun *et al.*[5]

In their discussion of the systematics of the even-even Ge nuclei, Lebrun *et al.*[5] conclude from a comparison of (p,t) and (t,p) strengths to the 0_2^+ states that there is a shape transition between ^{72}Ge and ^{74}Ge. This possibility had been suggested previously by several authors.[2,7,8] Ardouin *et al.*[7] performed constrained Hartree-Fock calculations using the Skyrme interaction. The results indicated that ^{68}Ge was an oblate rotor, ^{76,78}Ge were prolate rotors, and that there was only a small energy difference between the oblate and prolate minima in the potential energy surface for ^{72}Ge.

Later, calculations were made by Kumar[9] using a dynamic-deformation Nilsson-plus-pairing model. These calculations indicated that ^{70}Ge is a spherical but very soft nucleus, ^{72}Ge is an oblate transitional nucleus, and ^{74}Ge is an oblate deformed nucleus. Our deduced level scheme for ^{78}Ge is compared in Sec. IV with calculations[10] using this model. Apparently, the occurrence of supersoft nuclei and shape transitions is correlated with the energy of the 0_2^+ state.[5,8,9] In the even-even Ge isotopes, the energy of this state rises from a sharp minimum of 688 keV at ^{72}Ge to 1483 keV in ^{74}Ge and 1911 keV in ^{76}Ge, but falls to 1547 keV in ^{78}Ge. From this behavior, Mateja *et al.*[2] conclude that ^{78}Ge may be returning toward a critical or supersoft shape.

This paper reports a study of the decay of ^{78}Ga to levels in ^{78}Ge. Preliminary results have been given earlier.[11] The experiment was made possible by the development of an in-beam integrated target ion source used with the TRISTAN on-line mass separator system.[12,13] The Ga isotopes were produced by thermal neutron fission of ^{235}U. This investigation is the first in a series of studies with the objective of understanding the structure of even-even Ge nuclides out to $N = 50$.

II. EXPERIMENTAL METHODS AND RESULTS

The sources of mass-separated ^{78}Ga were produced with the TRISTAN II on-line mass separator located at the Ames Laboratory Research Reactor. The TRISTAN system was essentially the same as that described earlier,[12] except for the new in-beam integrated target ion source whose capabilities have been described by Talbert *et al.*[13] The target, consisting of 2 g of ^{235}UO$_2$, was positioned in a neutron beam of 2×10^9 n/cm^2 s. It was possible to separate the Zn and Ga fission products with good yields. A low energy photon spectrum (LEPS) and Ge(Li) γ-ray detectors were used for γ-singles measurements. γ-γ coincidence and γ-spectrum multiscaling measurements were carried out using large volume Ge(Li) detectors. The mass-separated $A = 78$ activity was collected on an aluminized-Mylar tape mounted in a moving tape collector.

For multiscaling measurements, 16 time bins, each 0.8 s in duration, were used. Counting started 1 s after the end of a 10 s collection period. Subsequently, a new source was collected and the procedure was repeated for a total running period of 7.5 h. A decay curve for the strong 619-keV γ ray from ^{78}Ga decay is shown in Fig. 1. The results of a least-squares fit to the data is shown by a solid line. In the fit it was assumed that some of the ^{78}Ga was derived from the decay of ^{78}Zn. The ^{78}Zn half-life used in the fit was fixed to 1.47 s as measured in this laboratory.[14] The ratio of ^{78}Zn and ^{78}Ga activities was a free parameter in the fit. The value obtained for the ^{78}Ga half-life was 5.49 ± 0.25 s, which is in fair agreement with a value of 5.09 s determined by Aleklett *et al.*[1]

Since both ^{78}Ga and ^{78}Zn activities were present in our samples, two different γ-singles measurements were made, each measurement lasting about 7 h. In a near-equilibrium ("parents") run, activity was simultaneously collected and counted for 60 s, after which the tape was moved and the procedure repeated. In the Ga-enhancement ("daughter") run, activity was collected for 10 s,

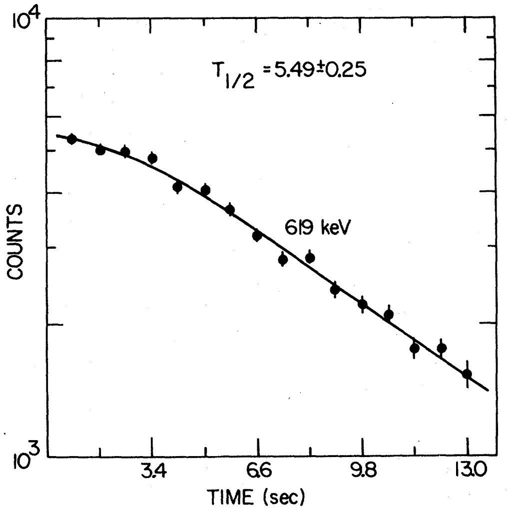

FIG. 1. Decay curve for the 619-keV γ ray from ^{78}Ga decay.

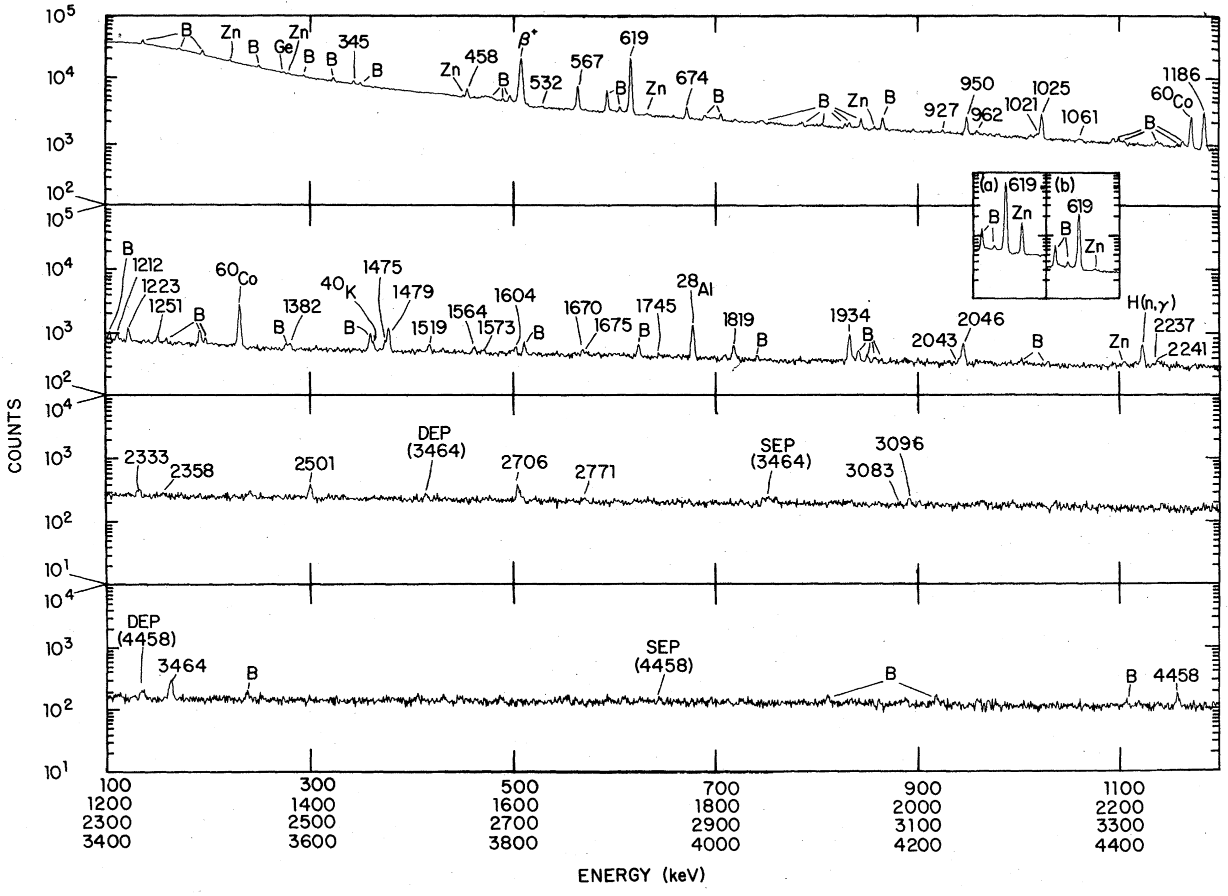

FIG. 2. γ-ray spectrum of mass 78 with ^{78}Ga enhanced. Background and ^{78}Zn decay lines are indicated by the symbols B and Zn, respectively. A comparison of the 619-keV ^{78}Ga and 635-keV ^{78}Zn γ rays is given in the insert.

TABLE I. γ transitions observed in ^{78}Ga decay.

E_γ (keV)	σ_E (keV)	I_γ [a]	σ_I	Placement (keV)
345.76	0.26	68.2	10.0	2665 – 2319
458.00	0.15	76.2	4.1	1644 – 1186
532.7	0.4	3.08	0.92	3389 – 2857
567.06	0.16	236.5	11.8	1186 – 619
619.40	0.16	1000.0	46.0	619 – 0
674.86	0.17	82.2	3.8	2319 – 1644
862.8	1.5[b]	10.6	5.0[c]	2705 – 1842
891.3	1.6[d]	4.4	2.5[b]	2438 – 1546
927.2	0.3	12.82	2.65	1546 – 619
950.77	0.17	98.0	4.9	1570 – 619
962.5	1.5[e]	9.9	5.0[e]	4083 – 3120
1021.2	0.4	15.8	4.3	2665 – 1644
1025.11	0.17	161.3	8.8	1644 – 619
1061.9	0.4	8.83	2.63	2705 – 1644
1186.42	0.16	260.9	11.9	1186 – 0
1212.41	0.24	25.6	3.4	2857 – 1644
1223.36	0.18	59.8	4.9	1842 – 619
1251.96	0.20	24.38	2.82	2438 – 1186
1308.4	0.3	4.58	2.26	2952 – 1644
1382.6	0.9	8.8	8.0	2952 – 1570
1475.5	0.4	18.2	7.3	3120 – 1644
1479.13	0.18	106.8	7.1	2665 – 1186
1519.32	0.24	20.7	3.2	2705 – 1186
1564.15	0.26	15.61	2.34	4270 – 2705
1573.4	0.3	13.52	2.50	4279 – 2705
1604.38	0.23	20.81	2.97	4270 – 2665
1670.67	0.23	21.27	2.59	2857 – 1186
1675.2	0.3	10.95	2.26	unplaced
1745.4	0.4	9.37	2.21	3389 – 1644
1819.59	0.21	37.4	5.6	2438 – 619
		9.8	4.0[b]	3389 – 1570
1934.10	0.21	120.9	7.5	3120 – 1186
2043.1	0.4	17.06	3.2	3687 – 1644
2046.32	0.25	72.1	7.4	2665 – 619
2237.9	0.4	16.0	3.4	2857 – 619
2241.0	0.6	11.1	3.3	4083 – 1842
2333.3	0.4	23.3	3.6	2952 – 619
2358.3	0.5	13.4	3.0	unplaced
2501.4	0.3	32.9	5.6	3120 – 619
		8.0	4.0[e]	3687 – 1186
2706.2	0.4	43.8	4.8	2705 – 0
2771.2	0.6	16.8	3.5	3389 – 619
3083.0	1.5	5.1	3.1	4270 – 1186
3092.8	0.7	23.1	3.9	4279 – 1186
3464.3	0.8	56.8	7.1	4083 – 619
3508.4	1.6[f]	1.2	0.8[f]	5078 – 1570
4458.5	1.2	16.8	3.0	5078 – 619

[a] Intensities normalized to 1000 for the 619-keV γ ray. The conversion factor to normalize to 100 ^{78}Ga decays is 0.076 65.

[b] Determined from spectrum in coincidence with the 619-keV γ ray.

[c] Determined from spectrum in coincidence with the 1223-keV γ ray.

[d] Determined from spectrum in coincidence with the 927-keV γ ray.

[e] Determined from spectrum in coincidence with the 567-keV γ ray.

[f] Determined from spectrum in coincidence with the 950-keV γ ray.

then a 5 s delay allowed the ^{78}Zn ($T_{1/2} = 1.47$ s) activity to almost completely die away, and finally the tape was moved to a shielded position for a 10 s count period. A background spectrum was measured in order to identify peaks caused by the fast neutron background.

A representative Ge(Li) daughter spectrum from 100 to 4500 keV is shown in Fig. 2. The parent spectrum had better statistics but the daughter spectrum was almost free of ^{78}Zn lines. No γ rays below 300 keV have been assigned to ^{78}Ga decay, therefore a LEPS spectrum is not shown. In the insert of Fig. 2, a comparison of the 619-keV ^{78}Ga and the 635-keV ^{78}Zn γ ray peaks in the parent and daughter spectra is given to indicate the relative enhancements. Some of the background peaks are identified by isotope, and one weak line from ^{78}Ge decay is indicated by Ge.

Standard sources of ^{56}Co, ^{182}Ta, and ^{226}Ra were used to calibrate γ energies and intensities and map the nonlinearities of the system. The energies, intensities, and placements of γ rays assigned to ^{78}Ga decay are given in Table I. A few of the γ-ray energies and intensities were determined from the coincidence spectra as indicated in Table I. γ-γ coincidence measurements for ^{78}Ga decay were carried out using two Ge(Li) detectors in 180° geometry. The collection tape was moved every 60 s to reduce buildup from long-lived activities. The run lasted 27 h and about 3×10^6 events were recorded. A coincidence timing

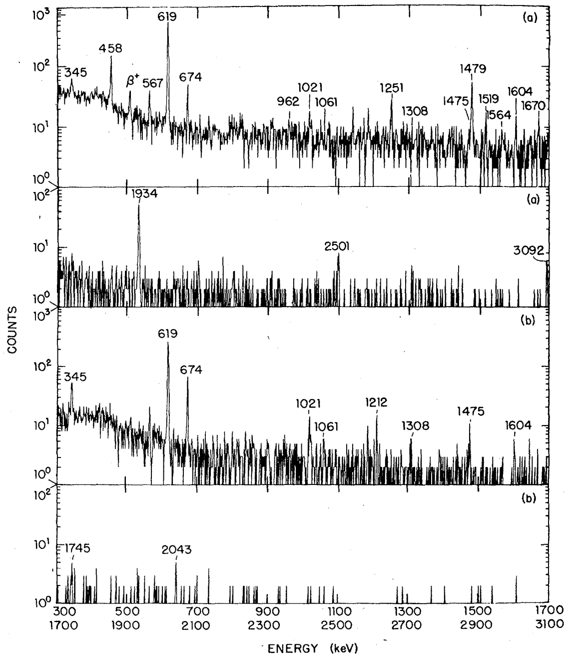

FIG. 3. Spectra in coincidence with the (a) 567-keV and (b) 1025-keV γ rays from ^{78}Ga decay.

TABLE II. $\gamma\gamma$ coincidences observed in ^{78}Ga decay.

Gating transition (keV)	Definitely coincident γ rays (keV)	Possibly coincident γ rays (keV)
345	458, 567, 619, 674, 1025, 1186, 1604	
458	345, 532, 567, 619, 674, 1061, 1186, 1212, 1308, 1475, 1604, 1745, 2043	1021
567	345, 458, 619, 674, 962, 1021, 1251, 1475, 1479, 1519, 1604, 1670, 1934, 2501, 3092	1061, 1308, 1564
619	345, 458, 567, 674, 862, 927, 950, 1025, 1212, 1223, 1251, 1308, 1382, 1475, 1479, 1519, 1564, 1604, 1670, 1819, 1934, 2046, 2237, 2241, 2333, 2501, 2771, 3464, 4458	891, 962, 1061, 1745 3092, 3508
674	345, 458, 567, 619, 1025, 1186	
927	619	891
950	619, 1382, 1819, 3508	
1025	345, 619, 674, 1021, 1061, 1212, 1308, 1475, 1604	1745, 2043
1186	345, 457, 674, 1021, 1251, 1475, 1479, 1519, 1573, 1934, 3092	1604, 2043, 2501
1212	458, 619, 1025	
1223	619, 862	
1251	567, 619, 1186	
1475 + 1479	567, 619, 1025, 1186, 1604	458, 962
1519	567	619, 1186, 1573
1564		567, 1186
1573	567, 619, 1186, 1519	
1604	345, 619, 1025, 1479, 2046	674, 1186
1670 + 1675	532, 567	1186
1745	619	
1819	619, 950	
1934	567, 619, 1186	962
2043 + 2046	458, 619	1025, 1186
2237 + 2241	1223	619
2333	619	
2501	567, 619, 1186	
2706	1573	
3092	567	619
3464	619	
4458	619	

window of 60 ns was used. A 4096×4096 channel array was used and spectrum in coincidence with selected peak and background gates were reconstructed by computer. Coincidence relationships were determined by visual comparison of peak and Compton-background gated spectra. Sample spectra for the 567- and 1025-keV γ-ray gates are shown in Fig. 3 and labeled (a) and (b), respectively. The coincidence results are summarized in Table II.

III. DECAY SCHEME

Results from our γ-ray singles and coincidence measurements described above were used to construct the decay scheme for ^{78}Ga shown in Fig. 4. Definite coincidences are shown by filled circles and possible coincidences are shown by open circles. A J^{π} of 3^{+} for the ^{78}Ga ground state is favored, as discussed below. In calculating log*ft* values we assumed zero β branching to the ground state. The β and γ intensities given in Fig. 4 are normalized to 100 ^{78}Ga decays. The conversion factor from Table I is 0.076 65. In the log*ft* calculation a Q_{β} of 7.89±0.16 MeV was used based on our reinterpretation of the β-γ coincidence measurements of Aleklett *et al.*[1] using our level scheme. The only change resulted from our interpretation of the 1479-keV γ ray as depopulation the 2665-keV level rather than the level at 3120

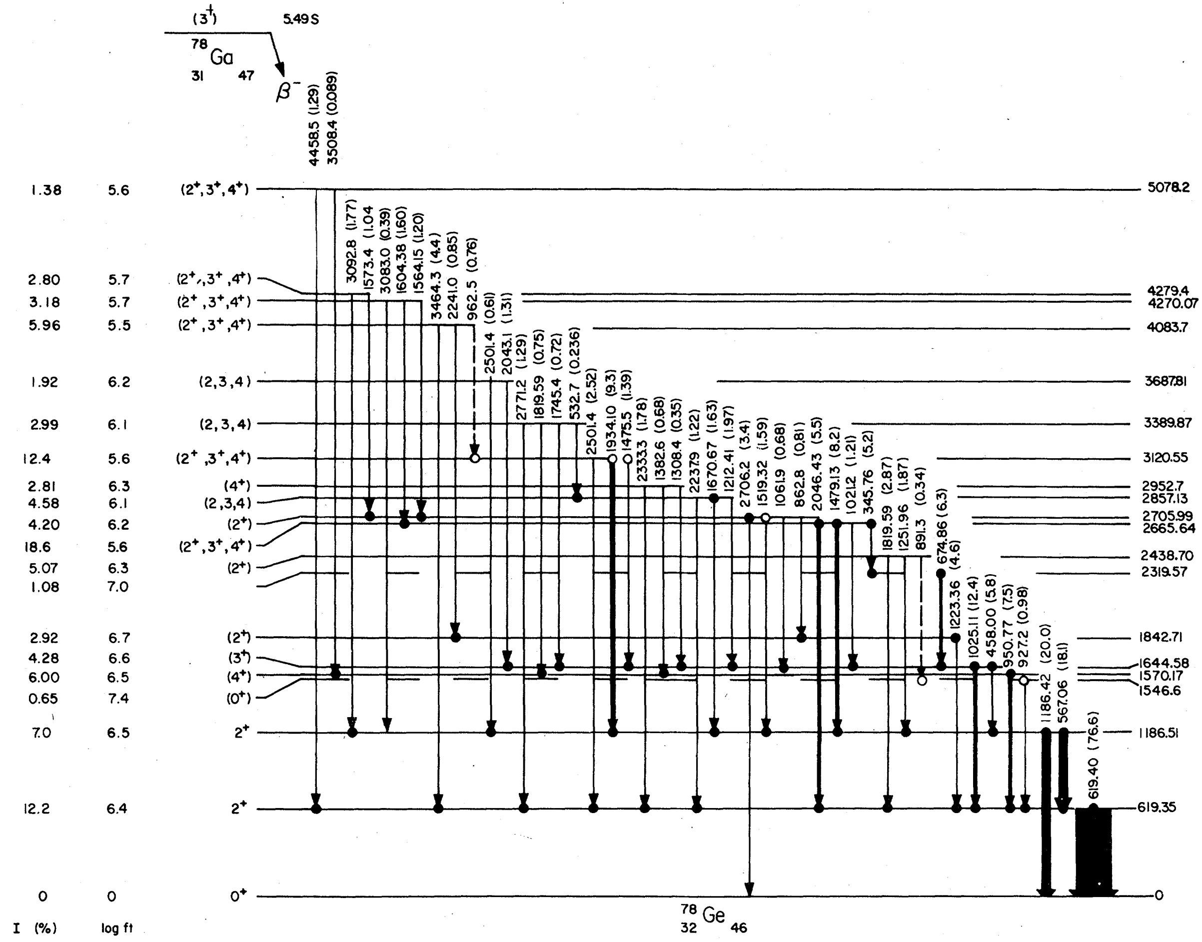

FIG. 4. Decay scheme for ^{78}Ga deduced from this work.

keV. The complete β branching, log*ft*, logf_1t, and level energy information is summarized in Table III. The level energies were computed by a procedure which minimizes

$$W=\sum_{j=1}^{N}\sum_{k=1}^{j-1}\frac{1}{\epsilon_{jk}^{2}}(E_j-E_k-E_{jk})^2\,,$$

where E_j and E_k are energy levels to be determined, N is the number of levels, E_{jk} is the energy of the γ connecting levels j and k, and ϵ_{jk} is the corresponding uncertainty. A discussion of the individual ^{78}Ge levels follows.

Ground states. The ^{78}Ge ground state is 0^+. Log*ft* values for β transitions to the (2+) 619-, (2+) 1186-, and (4+) 1570-keV levels indicate that the transitions must be allowed or first forbidden according to the rules of Raman and Gove.[15] This limits J^π for ^{78}Ga to 2^-, 3, 4^-. The logf_1t of 8.08 ± 0.08 for the level at 2705 keV with $J \leq 2$ (see discussion below) eliminates a first-forbidden unique transition, thus $J^\pi = 4^-$ for the ^{78}Ga ground state is ruled out. A similar argument can be made from the logf_1t of 8.13 ± 0.06 for the 2438-keV level if the J^π of 2^+ determined from the (t,p) reaction[2,3] is correct. Mateja *et al.*[2] observed a level at 2952 keV with $J^\pi = 4^+$; if this is correct, the logf_1t of 8.12 ± 0.12 rules out 2^- for the ^{78}Ga ground state.

The data on ^{78}Ge thus lead to the conclusion that $J = 3$ for the ground state of ^{78}Ga. Our study[14] of the decay of ^{78}Zn favors 3^+ over 3^-. Several 1^+ levels in ^{78}Ga are established by low log*ft* β branches in the decay of ^{78}Zn. Some of these 1^+ levels have ground-state γ transitions which would be of $M2$ multipolarity if the ground state were 3^-. These ground-state transitions are not weak compared to several other γ transitions depopulating 1^+ levels. Thus it is highly unlikely that the ^{78}Ga ground state is 3^-, since that would require $M2$ enhancement and/or strong hinderance of all of the competing transitions of $E1$, $M1$, or $E2$ multipolarity.

619.35-keV level. This level is depopulated by the strongest γ ray observed and is well estab-

TABLE III. β branching and logft values for ^{78}Ga decay.

Level energy (keV)	β branching (%)	Logft	logf_1t [a]
619.35 ± 0.12	12.2 ± 3.9	6.44 ± 0.14	8.56
1186.51 ± 0.12	7.0 ± 1.7	6.52 ± 0.11	8.57
1546.6 ± 0.3	0.65 ± 0.28	7.45 ± 0.19	9.45
1570.17 ± 0.19	6.00 ± 0.81	6.47 ± 0.07	8.47
1644.58 ± 0.14	4.28 ± 1.15	6.59 ± 0.12	8.59
1842.71 ± 0.21	2.92 ± 0.60	6.70 ± 0.10	8.66
2319.57 ± 0.19	1.08 ± 0.82	7.0 ± 0.3	8.86
2438.70 ± 0.18	5.07 ± 0.55	6.25 ± 0.06	8.13
2665.64 ± 0.16	18.6 ± 1.3	5.61 ± 0.05	7.45
2705.99 ± 0.19	4.20 ± 0.69	6.24 ± 0.08	8.08
2857.13 ± 0.19	4.58 ± 0.46	6.14 ± 0.06	7.96
2952.7 ± 0.3	2.81 ± 0.70	6.32 ± 0.12	8.12
3120.55 ± 0.19	12.4 ± 1.1	5.60 ± 0.06	7.37
3389.87 ± 0.22	2.99 ± 0.46	6.11 ± 0.08	7.83
3687.81 ± 0.27	1.92 ± 0.40	6.17 ± 0.10	7.84
4083.7 ± 0.5	5.96 ± 0.74	5.49 ± 0.07	7.08
4270.07 ± 0.22	3.18 ± 0.39	5.66 ± 0.07	7.21
4279.4 ± 0.3	2.80 ± 0.37	5.71 ± 0.08	7.26
5078.2 ± 1.0	1.38 ± 0.25	5.55 ± 0.10	6.90

[a] Uncertainties in logf_1t are identical to those in corresponding logft.

lished from (t,p) work[2,3] to be 2^+.

1186.51-keV level. This level decays to both the 0^+_1 and 2^+_1 states, which, along with systematics, strongly implies a $J^\pi = 2^+$ as has been inferred in (t,p) studies.[2,3]

1546.6-keV level. This level is based on the observation of the weak 927-keV γ ray in coincidence with the 619-keV γ ray. The level corresponds to one strongly excited in the (t,p) reaction[2,3] and determined to have J^π of 0^+. The β feeding to this level is small and could easily be zero if a small amount of γ strength into the level from high-lying states is not observed. The level is dashed due to the weak nature of the evidence in our data.

1570.17-keV level. This level was seen as part of a doublet with the one at 1546.6 keV in (t,p) studies[2,3] and has been assigned a J^π of 4^+. Our observation that the level is fairly strongly populated in ^{78}Ga decay but decays only to the 2^+_1 state is consistent with the 4^+ assignment for this level.

1644.58-keV level. This level is strongly populated by β and γ transitions in ^{78}Ga decay and is well established by numerous coincidences, but was not seen in (t,p) studies.[2,3] It is a good candidate for the 3^+ state predicted by Ardouin *et al.*[10] to lie in ^{78}Ge at about 1617 keV. The fact that this state γ decays only to the 2^+_1 and 2^+_2 states is consistent with this interpretation. Furthermore, if J^π for this state is 3^+, it would be an unnatural parity state and thus have a low cross section in the (t,p) reaction.

1842.71-keV level. This level was seen in (t,p) studies[2,3] and was determined to have a J^π of 2^+. The level was observed by us to deexcite only to the 2^+_1 level and is confirmed by several coincidences.

2319.57-keV level. This level is dashed due to the fact that the only evidence is the strong coincidence between the 674- and 345-keV γ rays and the level energy is based on the fact that the 674-keV γ ray is the more intense of the two. A multiplet was seen around this energy in both (t,p) studies, therefore the level may be one of the members of this multiplet.

2438.70-keV level. This level was seen in both (t,p) studies[2,3] and in each case a J^π of 2^+ was assigned. This is consistent with its observed γ decay to the 2^+_1, 2^+_2, and 0^+_2 levels. As discussed above, the logf_1t value of 8.13 ± 0.06 implies that J^π for the ^{78}Ga ground state is highly unlikely to be 4^-.

2655.64-keV level. This level is the most strongly fed in β decay, receiving 19% of the β branching. A logft of 5.61 ± 0.05 indicates an allowed β transition, therefore this level cannot be the one observed at a slightly lower energy in the (t,p) reaction[2,3] and assigned a J^π of 5^-.

2705.99-keV level. This level is the only one above 1200 keV that feeds the ^{78}Ge ground state. It was not seen in (t,p) work[2,3] but is well established by coincidences. The logf_1t value of 8.08 ± 0.08 rules out a J of 1 and the ground-state γ transition narrows the J assignment to 2. A J^π of 2^- is unlikely since this would imply an $M2$ multipolarity for the 2705-keV γ ray in competition with three $E1$ transitions.

2857.13-keV level. This level is well established by coincidences but probably does not correspond to one observed in (t,p) by Ardouin *et al.*[3] at 2850 keV and assigned a J^π of 5^-. A logf_1t value of 7.96 ± 0.06 limits J to 2, 3, or 4.

2952.7-keV level. This level was observed in both (t,p) studies.[2,3] Mateja *et al.*[2] assigned it a J^π of 4^+. If this J^π assignment is correct, a logf_1t of 8.12 ± 0.12 eliminates a J^π of 2^- for the ^{78}Ga ground state.

3120.55-keV level. This level was not excited in (t,p) studies[2,3] but the β intensity to the level was 12% of the total, the second strongest ^{78}Ga β branch. A logf_1t value of 7.37 ± 0.06 limits J to 2, 3, or 4.

A total of six levels were obtained above 3200 keV. All have logf_1t values well below 8.5, therefore their J values are limited to 2, 3, or 4. Of these, our level at 3389 keV may correspond to one seen at 3386 keV by Mateja *et al.*[2] and our level at 3687 keV may correspond to one seen at 3684 keV by Ardouin *et al.*[3]

In the preceding, arguments based on log*ft* values were used in making J^π assignments. Since 100% of the β branching was found in the present study to go to levels below 5 MeV in a decay with a Q_β of 7.9 MeV, the question arises about the magnitude of β branching to higher energy levels, which, if significant, could invalidate our log*ft* arguments. However, β strength function measurements of Aleklett *et al.*[16] indicate that only $\frac{1}{3}$ of the β branching goes to levels above 4 MeV and only $\frac{1}{5}$ goes to levels above 5 MeV. Assuming that the γ transitions out of these higher energy levels are statistically distributed, the effect of unobserved β branches would cause an increase of only about 0.1–0.2 in log*ft* values, and hence would not invalidate any of our log*ft* arguments.

IV. DISCUSSION

In Fig. 5, levels up to 3 MeV in ^{78}Ge determined in this work are compared with results from recent ^{76}Ge(t,p) studies[2,3] and with a dynamic deformation model calculation.[9,10,17] For excitation energies up to 2 MeV our work confirms the (t,p) results and adds a new level at 1644 keV. According to the model,[10] a 3^+ level is predicted to occur at 1617 keV. A J^π of 3^+ for the 1644-keV level is consistent with our results, although J values of 2 and 4 cannot be excluded. The J^π value of 3^+ is also consistent with the fact that the level was not observed in the (t,p) spectra, since it is an unnatural parity state. Between 2 and 3 MeV the levels deduced in this work at 2438 and 2952 keV were apparently observed in the $(t,p)^{2,3}$ studies as well.

Calculations[10] for the theoretical spectrum shown in Fig. 5 were made using the model of Kumar *et al.*[9,17]. In this model the potential energy surfaces and mass parameters are computed microscopically with pairing effects included. Each final state is an admixture of intrinsic states with different deformations. Only even parity states were calculated.

The model predictions up to 2 MeV are quite good in that there is a one-to-one correspondence between calculated and observed levels, the calculated level ordering is correct, and the calculated energies are reasonably close to experimental values. The observed levels at 2438 and 2705 keV may correspond to the model predictions at 2253 and 2663 keV. Since selection rules limit the levels populated by β decay primarily to J values of 2, 3, and 4, the number of levels up to 3 MeV is also in agreement with the model.

A more sensitive test of the model would be a comparison of predicted transition rates with experimental branching ratios. This would also help delineate band-like structures which may exist in the nucleus. At present, theoretical branching ratios have not been calculated using this model.[10] Such a comparison would be of particular interest for levels below 2 MeV, where there is a clear correspondence between predicted and experimental levels.

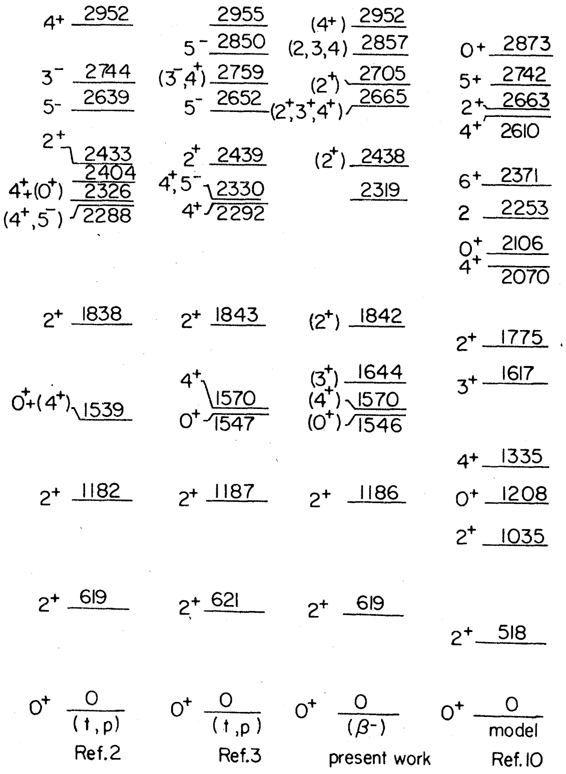

FIG. 5. Comparison of levels in ^{78}Ge up to 3 MeV from the (t,p) reaction, β^- decay, and a dynamic deformation model.

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