^{73}Ge(d,^{3}He)^{72}Ga reaction

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The odd-odd nucleus ^{72}Ga has been studied via the ^{73}Ge(d,^{3}He)^{72}Ga reaction at 25.2 MeV, with 9 keV resolution full width at half maximum, using a tandem accelerator and a split pole spectrometer. The spectroscopic factors are determined for 40 levels, some of which were previously unknown. All the observed levels have negative parity; limits for the spin value J are given and possible main configurations are suggested for some levels. The occupation numbers of the proton orbitals in ^{73}Ge have been determined: this nucleus appears in this respect as more similar to the heavier even Ge isotopes than to the lighter ones.

I. INTRODUCTION

The ground state structure of the even Ge isotopes is known to change[1,2] when the neutron number N varies from 40 to 42. The main evidence for this change comes from the variation of the occupancies of the $p_{3/2}$ and $f_{5/2}$ proton subshells measured[1] in the (d,^{3}He) reaction and from the behavior of the distribution of the $L=0$ strength of the (p,t) and (t,p) reactions.[2] The behavior of the distribution of the $L=0$ strength in the same (t,p) and (p,t) reactions[2,3] on Ga targets indicates a similar change between $N=40$ and 42 for the Ga isotopes. It may then be interesting to investigate what happens in between, for the $N=41$ isotones ^{73}Ge and ^{72}Ga.

The change of structure observed in the Ge isotopes has been described,[4] using a very simple proton wave function, as being mainly due to the strong and correlated variation in the occupancies of the $p_{3/2}$ and $f_{5/2}$ proton orbitals between ^{72}Ge ($N=40$) and ^{74}Ge ($N=42$). Measurement of the spectroscopic strengths in the ^{73}Ge(d,^{3}He)^{72}Ga reaction may permit an estimation of these occupancies also for the ^{73}Ge ground state and then a determination of whether the proton part of the ^{73}Ge ground state wave function is similar to that of ^{72}Ge or to that of ^{74}Ge, or intermediate. The occupancies could in principle be deduced from the existing results of the proton stripping reaction on the same target. However, such an analysis of the results obtained by Rosner *et al.*[5] for the ^{73}Ga(^{3}He,d)^{74}Ge reaction cannot reliably be performed, mainly because their total $l=1+3$ measured strength reaches only 5.65 instead of the total hole number of 8. New data are therefore clearly needed.

The level scheme of the odd-odd ^{72}Ga nucleus is known,[6] but rather incompletely, from studies of the β decay of ^{72}Zn,[7] the thermal neutron capture γ rays,[8] and the neutron stripping reaction[9] ^{71}Ga(d,p)^{72}Ga. The proton pickup reaction ^{72}Ge(d,^{3}He)^{72}Ga, studied in the present work, is going to bring complementary information.

II. EXPERIMENTAL PROCEDURE

The reaction was studied at 25.2 MeV incident energy using a 1 μA deuteron beam from the Orsay MP tandem accelerator. The target consisted of GeO_2, isotopically enriched to 94.4% in ^{73}Ge, evaporated onto a thin carbon foil. The experimental setup was the same as in previous studies of the (d,^{3}He) reaction on the even Ge and Se targets.[1,10] The ^{3}He particles were analyzed and detected in the focal plane of a split-pole magnetic spectrometer, using solid state position sensitive detectors. A typical spectrum is shown in Fig. 1. The overall resolution is 9 keV full width at half maximum. Data were taken over an angular range from 5° to 33° in 4° steps. The normalization was performed using the elastic scattering peak measured with a solid state monitor detector set at an angle of 105° from the incident beam direction. The absolute cross sections were obtained from a comparison of the experimental angular distribution for deuteron elastic scattering (measured in the angular range 15° to 25°) with optical model predictions. The resulting uncertainty in absolute cross section is estimated to be 15%.

The angular distributions are compared in Fig. 2 with distorted wave calculations performed using the code DWUCK,[11] with the parameters already used in the previous analysis of the (d,^{3}He) reaction on the even Ge targets.[1] The standard normalization factor of 2.95 has been used.

Complementary (d,^{3}He) measurements, performed on a natural Ge target, have permitted a determination of the relative values of the spectroscopic factors for the strongly populated levels: the ground state and the 873 keV level of ^{69}Ga, the ground state of ^{71}Ga, and the 169, 275, and 399 keV levels of the ^{72}Ga. Normalizing these relative spectroscopic factors to get for the levels of ^{72}Ga the "absolute" values measured as described above with the ^{73}Ge enriched target, we have obtained for the spectroscopic factors of the observed levels of ^{69}Ga and ^{71}Ga values in agreement—within less than 5%—with the ones already

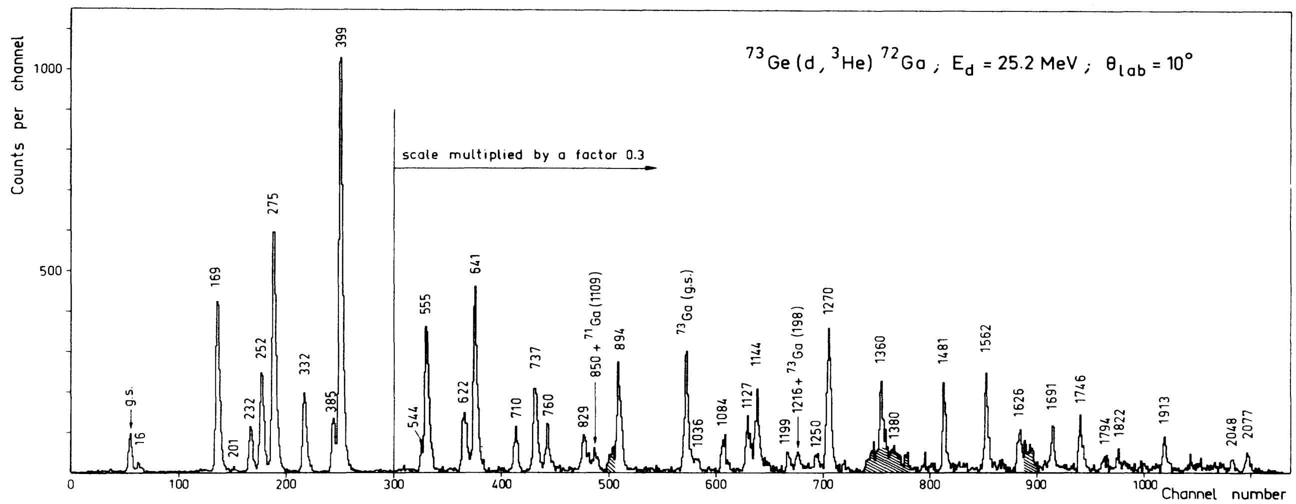

FIG. 1. Spectrum of the ^{3}He particles emitted in the $^{73}Ge(d,^{3}He)^{72}Ga$ reaction. Observed levels are labeled by their excitation energy in keV. Hatched peaks correspond to light impurities.

determined in the previous study[1] of the even Ge isotopes. This confirms the reliability of the present "absolute" values (errors estimated to be of the order of 20% or smaller) and particularly the validity of a comparison between the present values for ^{73}Ge and the old values of Ref. 1 for the even Ge targets.

III. SPECTROSCOPIC RESULTS

The spectroscopic results obtained for the levels of ^{72}Ga are presented in Table I, where they are compared with previous results[6] obtained by β, γ measurements in the β decay of ^{72}Zn,[7] by studies of thermal neutron capture γ rays from the $^{71}Ga(n,\gamma)^{72}Ga$ reaction,[8] or by means of the $^{72}Ga(d,p)^{72}Ga$ neutron stripping reaction.[9]

As shown in Fig. 1, many peaks are observed in the $(d,^{3}He)$ reaction up to about 2 MeV excitation energy, 40 of which can be assigned to levels of ^{72}Ga. For comparison, in the $(d,^{3}He)$ reaction on each even Ge target,[1] only about 11 levels were observed in the same energy range. In counterpart, individual cross sections are smaller for the reaction on ^{73}Ge, a similar strength being distributed among many more levels. Moreover, in the reaction on the even Ge isotopes, the observed l transfers were (except for one weakly populated level with $l=4$ in each isotope) either pure $l=1$ or pure $l=3$, while l mixing cannot be excluded in the reaction on ^{73}Ge ($J^{\pi}=9/2^{+}$). In fact, all the observed angular distributions can be fitted either by an $l=1$ transfer, an $l=3$ transfer, or a mixture of $l=1$ with $l=3$. However, for weakly populated levels, ambiguities may result from large statistical uncertainties, and in certain cases, at some angles, from a contamination due to the reaction on a light impurity. For such levels no l value is given in Table I, but the possible $l=1$ or $l=3$ spectroscopic factors are given within parentheses. For most angular distributions, the best fit is obtained with a mixing of $l=1$ and $l=3$, but, even in this case, a single l often gives an acceptable fit. [It should be remarked that, in the reaction on the even Ge isotopes[1] where each level can be populated only by a single l transfer, addition of a second (forbidden) l value would in some cases artificially improve the fit.] Two l values are given in Table I when the best fit is obtained with an l mixing, but the second value is given within parentheses when the first value, alone, gives an acceptable fit. An uncertainty on the spectroscopic factors results from the uncertainty on the mixing; the extreme values resulting from this uncertainty are given in Table I. As can be seen, the resulting uncertainty on the spectroscopic factors is rather small for the $l=1$ transfer but large for the $l=3$: the deduced value for the whole observed $l=1$ spectroscopic strength lies between 1.86 and 2.13, while the corresponding $l=3$ strength lies between 6.42 and 2.66.

IV. OCCUPANCY OF THE PROTON ORBITALS IN THE $^{73}Ge_{g.s.}$ WAVE FUNCTION

If the $Z=28$ shell is really a closed shell, there are only four valence protons in the Ge isotopes ($Z=32$). The sum rules of Macfarlane and French[12] then predict that the total spectroscopic strength corresponding to the valence proton orbitals is 4. The proton transfer reactions on the even Ge targets[1,12] have shown that the $2p_{1/2}$, $2p_{3/2}$, and $1f_{5/2}$ proton orbitals can, to good approximation, be considered as the only active valence orbitals, since only a weak $l=4$ transition was observed in pickup[1] and only a weak transition strength corresponding to $J^{\pi}=7/2^{-}$ was observed in stripping;[13] the total $2p$, $1f_{5/2}$ strength obtained in pickup was indeed[1] very close to 4.

The information deduced from the present results on the odd ^{73}Ge target cannot be as precise as in the case of the even targets, mainly because the spin-parity value of the target is $J^{\pi}=9/2^{+}$. A consequence, as indicated above, is the occurrence of l mixing which leads to additional uncertainties in the measured spectroscopic factors.

As shown in Sec. III, this additional uncertainty is rather weak for $l=1$ transfer, but is very large for $l=3$ transfer. Moreover, even if this uncertainty was not so large, no distinction can be made between an $l=3$ transfer on the active valence $1f_{5/2}$ orbital and an $l=3$ transfer on the deeper $1f_{7/2}$ shell (the distinction could be made in the reaction on the even Ge targets, when the spin of the final level was known). As a result, the measured $l=3$ spectroscopic strengths cannot be used to precisely determine the occupancies and we shall attempt to deduce them from

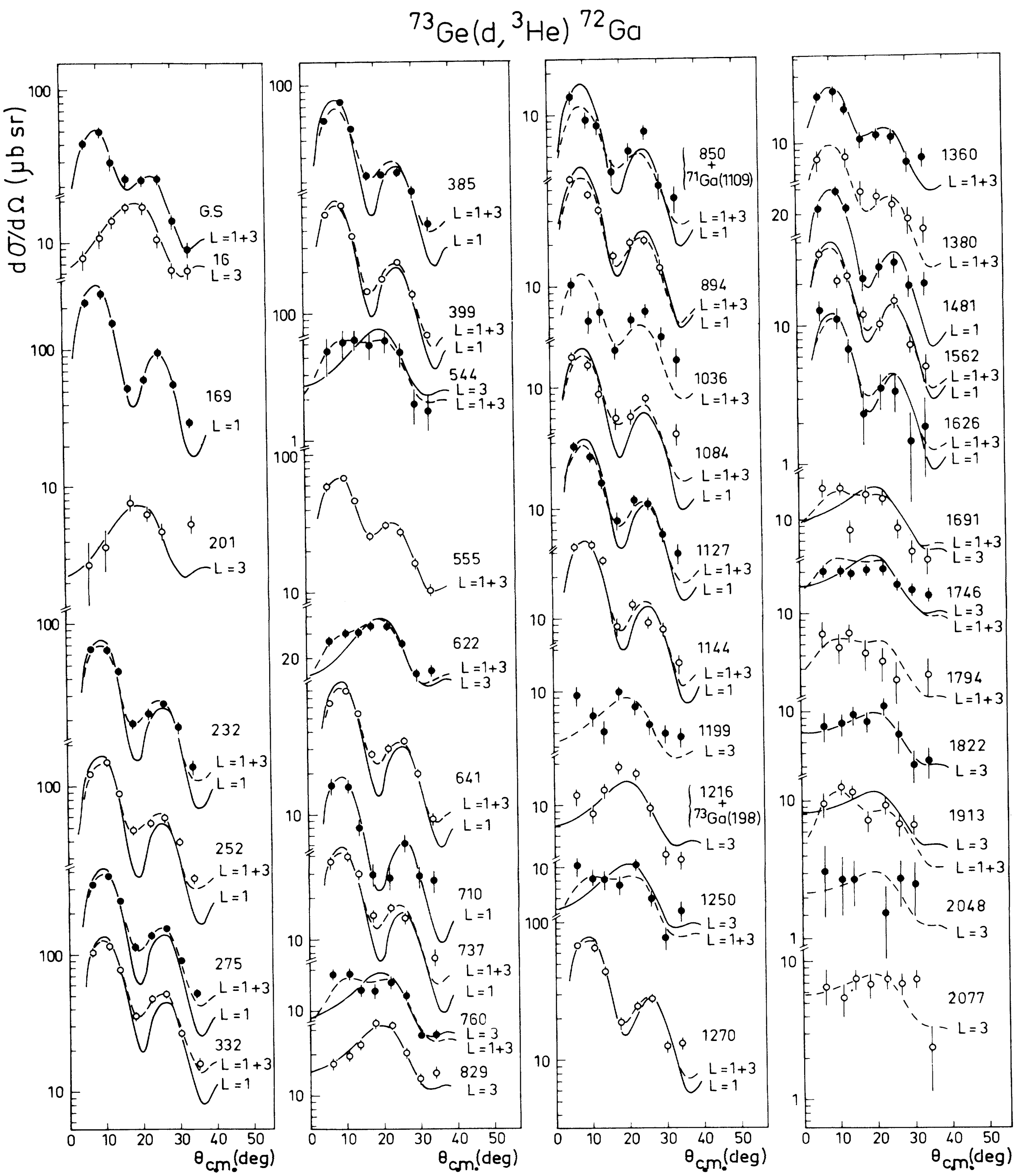

FIG. 2. Angular distributions of the ^{3}He particles from the ^{73}Ge(d,^{3}He)^{72}Ga reaction. The curves are the results of DWBA calculations. For the few weakly populated levels with questionable l attribution, the DWBA prediction is shown as a dashed curve. If the best fit corresponds to a mixture, but a single l already gives an acceptable fit, the corresponding two curves are shown (dashed and continuous curves, respectively).

TABLE I. Comparison of present and previous results concerning the ^{72}Ga levels.

	Present work			From (d,p)			From γ rays	
E_x (keV)[a]	l[b]	C^2S ($l=1$)	C^2S ($l=3$)	E_x (keV)[c]	l	C^2S	E_x (keV)[c]	J^{π}[d]
0	1+3	0.03	0.15–0.08				0.0	3^-
16	3		0.18				16.46	2^-
							119.68	(0^+)
							128.81	1,2
				162	1	0.06	161.57	1^+
169	1	0.21					[165.5][e]	4^-–6^-
201	3		0.08				197.97	1^-–4^-
				208	1	0.04	208.51	1^+
232	1 (+3)	0.05–0.06	0.08–0[f]				228.79	$3^-,4^-$
252	1 (+3)	0.10–0.11[f]	0.36–0	250	4	2.75	248.95	$3^-,4^-$
275	1 (+3)	0.28–0.32	0.65–0	274	[2+4][g]	[0.07,1.1][g]	[271.9][e]	(4^-)
							282.59	
332	1 (+3)	0.09–0.11	0.22–0	331	4	0.38	330.29	$3^-,4^-$
385	1 (+3)	0.047	0.17–0.05					
							392.57	
399	1 (+3)	0.46–0.52	0.70–0	400	4	2.66		4^-–6^-
							408.15	
							512.98	
							514.3	
544	3	0	0.08					4^-–8^-
555	1+3	0.05–0.06	0.26–0.13					4^-–6^-
				560			564.28	
				605	1	0.08	600.70	
622	3 (+1)	0–0.008	0.51–0.50				619.52	1^-–4^-
641	1 (+3)	0.07–0.08	0.16–0	639	4	0.41	636.8	$3^-,4^-$
710	1	0.02		709	4	0.65		4^-–6^-
737	1 (+3)	0.04	0.09–0				737.75	$3^-,4^-$[h]
				741	2	0.09	741.25	0^-–3^-[h]
760	3 (+1)	0–0.007	0.25–0.22					4^-–8^-
829	3		0.46				(829)	
(850)[i]	1 (+3)	[0.10][i]						
				856	1	0.2	857	
894	1 (+3)	0.06–0.07	0.05–0				894	$3^-,4^-$
				900	3	0.7		
				917			919	
				983	1	0.03	979	
1036		(0.012)	(0.03)				1033	
				1061	1	0.09	1060	
1084	1 (+3)	0.02	0.04–0					
1127	1 (+3)	0.03	0.05–0				(1130)	
1144	1 (+3)	0.04	0.04–0					
				1150	1	0.04	1150	
1199			(0.17)					
				1208			1206	
(1216)[i]	3		[0.15][i]				(1217)	
1250	3 (+1)	0–0.004	0.17–0.14				(1249)	
1270	1 (+3)	0.09–0.10	0.08–0	1267	2	0.15	1263	
				1338				

the $l=1$ spectroscopic strength alone.

For the $l=1$ transfer, the angular distribution does not permit discrimination between the two possible transferred j (1/2 or 3/2). The value of the total measured $l=1$ spectroscopic strength has been found to lie between 1.86 and 2.13, assuming $j=3/2$ for each $l=1$ transfer. The $l=1$ spectroscopic factor has to be multiplied by a factor 1.2 if the transferred spin is 1/2 instead of 3/2. If the proportion of $2p_{1/2}$ strength (as compared to $2p_{3/2}$) is assumed to be the same in the reaction on ^{73}Ge as in the reaction on the even Ge targets, the deduced limits for the total $l=1$ spectroscopic strength are then increased to the values 1.96–2.24. This represents the extreme possible values of the occupancy of the $2p$ or-

TABLE I. (*Continued*).

	Present work			From (d,p)			From γ rays	
E_x (keV)[a]	l[b]	C^2S ($l=1$)	C^2S ($l=3$)	E_x (keV)[c]	l	C^2S	E_x (keV)[c]	J^{π}[d]
1360	1+3	0.02–0.03	0.17–0.05				(1360)	
1380		0.006–0.011	0.05–0.02	1380	2	0.03		
				1435	3	1.7		
							1473	
1481	1	0.04						
				1517			1516	
1562	1 (+3)	0.05–0.06	0.05–0	1558	2	0.1		
				1592	0	0.03		
1626	1 (+3)	0.02	0.01–0				1630	
				1633	0	0.03		
				1685	3	1.1	1681	
1691	3 (+1)	0–0.008	0.36–0.29					
				1732			1728	
1746	3 (+1)	0–0.013	0.50–0.40	1752	2	0.06	1750	
				1782	2	0.06	1777	
1794		(0–0.004)	(0.12)	1798	0	0.04	1802	
1822	3		0.22				(1816)	
				1872			1870	
1913	3 (+1)	0–0.006	0.26–0.18	1919			1918	
				1989				
2048			(0.08)				(2043)	
				2059			2056	
2077			(0.21)				(2073)	

[a]The uncertainty in the values of the excitation energies is estimated to be less than 4 keV below and up to 1 MeV, and to be less than 6 keV above 1 MeV.

[b]The second l value, when given within parentheses, may correspond to a spurious component (see the text). Accordingly, the range of values for the corresponding spectroscopic factor extends down to zero.

[c]From Ref. 9 for the (d,p) reaction. From Ref. 6 for the γ rays when not otherwise indicated. Levels considered as dubious in Ref. 6 are not reported in the table, unless an identification with a level observed in (d,^{3}He) is possible. Then, they are given within parentheses.

[d]J^{π} values assigned (Ref. 6) from previous results, and possible J^{π} limits for levels observed in (d,^{3}He). For a level populated by an $l=1$ or an $l=1+3$ transfer, the possible values are 3^- or 4^- if it can be identified with a level populated by a primary γ ray in the ^{71}Ga(n,γ) reaction; 4^-–6^- if it is not populated by a direct γ ray. For a level populated by a pure $l=3$ transfer, the corresponding limits are, respectively, 1^-–4^- and 4^-–8^-. For levels above 1 MeV, identification has not been attempted.

[e]Assignment of observed (Ref. 8) γ rays to the decay of suggested levels at 165.5 and 271.9 keV is discussed in Sec. V.

[f]A small part of the observed peak is due to a contribution from another isotope. The spectroscopic factor has been corrected for this contribution.

[g]No l assignment for this level in Ref. 9. See discussion in Sec. V for the present assignment. Corresponding spectroscopic factors are given.

[h]The spin-parity value is limited to 3^- or 4^- for the level observed with the (d,^{3}He) reaction; it is limited to 0^-–3^- for the one observed with the (d,p) reaction. In both cases the resolution is not good enough to permit identification of which one of the two members of the doublet (737.75 and 741.25 keV) is populated in each reaction. If it is the same in the two cases, its spin parity is 3^-.

[i]A large part (about one half) of the observed peak is due to a contribution from another isotope. Although the given spectroscopic factor has been corrected for the evaluated contribution, the result has to be taken with caution.

bitals if the two following conditions are fulfilled: (i) the full $l=1$ strength is really observed; (ii) the absolute normalization of the cross sections is good. The first condition is expected to be fulfilled because the spectrum has been studied as high in excitation energy as in the reaction on the even isotopes and because, moreover, the observed $l=1$ strength appears to be concentrated in the low lying part of the excitation energy spectrum. The complementary measurements on the natural Ge target, also reported in Sec. II, show quite convincingly that the second condition can also be considered as reasonably fulfilled.

The total occupation numbers of the $2p$ orbitals in all the stable Ge isotopes are compared in Fig. 3. Although there are more uncertainties in the case of ^{73}Ge, its ground state wave function appears to be closer to that of the heavy Ge isotopes than to that of the light ones.

V. LEVELS OF ^{72}Ga

As the spin value of the target is $J^{\pi}=9/2^+$, the determination of the l, or even of the j, transferred angular momentum does not permit, alone, a determination of the

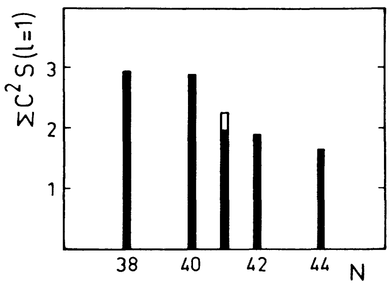

FIG. 3. Proton occupation numbers of the $2p$ orbitals in the stable Ge isotopes as measured via the (d,^{3}He) reaction. The open part of the bar for $N=41$ (^{73}Ge) represents the uncertainty due to l mixing.

spin of the final levels. As all the measured angular distributions correspond to transfer $l=1$, $l=3$, or to a mixture of $l=1$ and $l=3$, the observed levels all have necessarily negative parity. The final spin J may have any value between 3 and 6 for a level corresponding to a transfer $l=1$ or to a mixture of $l=1$ and $l=3$; it can have any value between 1 and 8 for a level corresponding to a transfer $l=3$ (the values are restricted between 2 and 7 if there is any reason to restrict the transfer to $f_{5/2}$).

If a level observed in the (d,^{3}He) reaction can be identified with a level observed also in the (d,p) reaction, or in (n,γ), a reduction of the possible values of its spin J may result. The excitation energies measured in the present experiment for 11 levels do not differ by more than 4 keV from values measured by Yntema[9] in the (d,p) reaction. For five of these levels the angular distribution observed in (d,p) corresponds to an $l=4$ transfer, the corresponding levels being populated by an $l=1$ (or by a mixture of $l=1$ and $l=3$) transfer in (d,^{3}He). The two reactions give then the same possibility: $J^\pi=3^- - 6^-$ with no further reduction. The possibilities for levels populated with $l=2$ in the (d,p) reaction are $0^- - 4^-$. If the levels observed at 737, 1270, and 1562 keV with a clear $l=1$ component in the (d,^{3}He) reaction are really the same as those observed with $l=2$ at 741, 1267, and 1558 keV in the (d,p) reaction, the spin possibility is restricted to $J^\pi=3^-$ or 4^- for these levels. The two weakly populated levels observed at 1380 and 1794 keV in (d,^{3}He) may be identified with the levels observed at 1380 keV ($l=2$, then $J^\pi=0^- - 4^-$) and at 1798 keV ($l=0$, then $J^\pi=1^-$ or 2^-) in (d,p). For the last of these 11 levels (275 keV), no l assignment was given from (d,p). However, the clear $l=1$ component observed in (d,^{3}He) shows the parity to be negative and limits the J value between 3 and 6. Because of this negative parity, the transfer in (d,p) is restricted to even l values. We have verified that the angular distribution can be reasonably reproduced by calculations with a mixture of $l=4$ and $l=2$ transfer. The spin value is then restricted to 3^- or 4^-. Two other levels observed with an $l=3$ component at 1746 and 1913 keV in (d,^{3}He) may tentatively be identified with the levels observed in (d,p) at 1752 with $l=2$ and at 1919 keV without l assignment. The three other negative parity levels observed in the (d,p) reaction at 1592, 1633, and 1782 keV are not seen in (d,^{3}He); the level observed at 1626 keV with an $l=1$ component in (d,^{3}He) has a spin value between 3^- and 6^- and cannot be identified with the level observed at 1633 keV with $l=0$ ($J^\pi=1^-$ or 2^-) in (d,p). No other level observed in (d,^{3}He) can be identified with a level observed in (d,p).

Other information comes from the detection of γ rays from thermal neutron capture ^{71}Ga(n,γ)^{72}Ga.[8] The excited levels formed by capture of a thermal neutron by ^{71}Ga ($3/2^-$) may only have $J^\pi=1^-$ or 2^-. The first excited emitted γ may be $E1$, $M1$, or perhaps $E2$; the levels populated by the primary γ rays may then be $J^\pi=0^\pm - 3^\pm$, (4^-). Levels observed both in (n,γ) and in (d,^{3}He) with $l=1$, or $1+3$ then have spin values $J^\pi=3^-$ or 4^-. The levels observed at 0, 232, 252, 332, 641, 737, and 894 keV with $l=1$ (or $1+3$) in (d,^{3}He) may be identified with levels observed in (n,γ); the identification is more dubious for levels above 1 MeV (1127, 1360, 1626 keV) because of the higher level density. The spin values 3^- or 4^- for the levels at 228.79, 248.95, 330.29, and 636.8 keV are consistent with the γ observed in their deexcitation[8] if the 210.33 keV γ ray (for which a double placement has been proposed[8]) does not correspond to a deexcitation from the 330.29 to the (0^+) 119.68 keV level. On the other hand, the decay scheme proposed[8] for each of the two levels with which our 737 keV level might be identified seems to be inconsistent with $J^\pi=3^-$ or 4^-: the 741.25 keV level decays to the 1^+ levels at 161.57 and 208.51 keV and the 737.75 keV level decays to the (0^+) level at 119.68 keV.

The level at 169 keV, which had never been observed before our work, deserves special discussion. It is populated by a clear $l=1$ transfer and has therefore a spin parity between 3^- and 6^- It has not been observed among the levels populated by primary γ rays in the (n,γ) reaction[8] and has therefore most probably $J\geq 4$. The spin parity is then restricted to the values 4^-, 5^-, or 6^-. The same is true for the levels observed at 275 and 399 keV in (d,^{3}He), with an $l=1$ component, and not observed in (n,γ). For the 275 keV level, the occurrence, discussed above, of an $l=2$ component in the (d,p) angular distribution further restricts the possibilities and leads to a probable assignment of $J^\pi=4^-$.

It is interesting to look at the low-lying γ rays observed after radiative capture. When looking carefully at our Table I it appears that our energies seem to be too high, by ≈ 3 keV, between 200 and 650 keV. Therefore the second or third γ ray by order of intensity,[8] with an energy of 165.51 keV, could well correspond to the ground state decay of our 169 keV level. The parent level of this γ ray has not been clearly identified, but Vervier and Bolotin[8] have suggested that it could be emitted in the decay of the 408.15 keV level, to a hypothetical level at 243.6 keV, itself deexcited by two γ rays in cascade, of 106.36 and 135.95 keV (much weaker than the 165.51 keV γ ray) going through an unknown intermediate level at 106.36 or 135.95 keV. We suggest instead that the observed 165.51 keV γ ray corresponds to the ground state decay of the level observed in the present work at 169 keV. If, as suggested above, this level has a spin parity 5^-

or 6^-, it would be natural that only the decay to the 3^- ground state has been observed, the spins of the intermediate levels being smaller than 3. The γ rays of 135.95, 106.36, and 165.51 keV could then be emitted in this order in the decay of the 408.15 keV level and the intermediate levels at 271.9 and 165.51 keV would correspond nicely to the levels observed in the present work at 275 and 169 keV.

Among the levels the population of which clearly involves an $l=3$ transfer, 11 appear to correspond to pure $l=3$ transfer. None of them, with one possible exception of the 1746 keV level (but the density of levels is already very high at this excitation energy), is populated in the (d,p) reaction. They can be divided into two groups, separated by a gap of about 400 keV. The first group contains five levels: 16, 544, 622, 760, and 829 keV, with a total spectroscopic factor $C^2S=1.3$ and a centroid of the observed strength $\tilde{E}=614$ keV. The second group contains six levels: 1216, 1250, 1691, 1746, 1822, and 1913 keV, with a total spectroscopic factor $C^2S=1.24$ and a centroid of the observed strength $\tilde{E}=1630$ keV. The occupancies of the proton orbitals being quite similar in ^{73}Ge and ^{74}Ge, it is interesting to compare the present results to those previously obtained[1] for $l=3$ transfer to low-lying levels of ^{73}Ga, via the $^{74}Ge(d,^3He)^{73}Ga$ reaction. The total spectroscopic factors and the difference in centroid energies given above compare reasonably well with the values observed for the $5/2_1^-$ and $7/2_1^-$ levels of ^{73}Ga: spectroscopic factors of, respectively, $C^2S(5/2^-)=1.87$ and $C^2S(7/2^-)=1.79$, separation of 1300 keV. This suggests that the main configuration of the ^{72}Ga levels discussed in this paragraph consists in the product of the "spectator" $9/2^+$ neutron configuration of the $^{73}Ga_{g.s.}$ by:

(a) the $5/2_1^-$ proton configuration of ^{73}Ga for the five lowest levels;

(b) the $7/2_1^-$ proton configuration of ^{73}Ga for the six highest levels.

In the first group the 16 keV level is clearly the 2^- member and the large values of their spectroscopic factors make the 622 and 829 keV levels good candidates to be the 6^- and 7^- members of the multiplet. In the second group the classification is not clear, but the 1746 keV level, with its large spectroscopic factor, is a good candidate to be the 8^- member of the multiplet.

VI. SUMMARY

The good resolution study of the odd-odd ^{72}Ga nucleus, via the $^{73}Ge(d,^3He)^{72}Ga$ reaction, has permitted observation of several previously unknown levels and measurement of the spectroscopic factors for 40 levels. As expected, the observed transfers are $l=1$, $l=3$, or $l=1+3$ This permits clear assignment of negative parity to all the observed levels.

Although the level density at high excitation energy precludes any unambiguous identification between the levels observed in the present work and in previous studies, such a comparison at low excitation energy permits for some levels a reduction in the possible values of J.

Due to mixing between $l=1$ and $l=3$ transfer, the extracted spectroscopic factors for $l=3$ transfer are in many cases rather uncertain. This is not true for the $l=1$ transfer, and the sum of the corresponding spectroscopic factors shows that the occupancies of the proton orbitals in ^{73}Ge are more similar to those of the heavier Ge isotopes than to those of the lighter ones.

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