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LOW-SPIN STATES OF $^{147}_{64}\mathrm{Gd}_{83}$ IN THE β-DECAY OF $^{147g}\mathrm{Tb}$

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1. Introduction

Establishment of the magic properties of the proton number Z=64 in the vicinity of the closed neutron shell N=82 [1-4] has stimulated extensive studies of the excited states of nuclei neighbouring on the double magic ${}^{146}_{64}Gd_{82}$ nucleus. Experimental data on properties of these nuclei provide a good possibility of checking the applicability of different approaches to the nuclear calculation. A good example of such nuclei is ${}^{147}Gd$, which is a particle (neutron) coupled to the double magic core ${}^{146}_{64}Gd_{82}$. A convenient way to study low-spin states of ${}^{147}Gd$ is to investigate β^+-decay of the $1/2^+$ ${}^{147}Tb$ isomer, which is the subject of this paper.

Two isomers of ${}^{147}Tb$ with $T_{1/2} = 1.6h$ and 1.8 min were discovered by Chu *et al.* [5]. Their spin, parity and energy $1/2^+$ for the 1.6 h ground state and $11/2^-$ for the 1.8 min 50.6 keV state, were proposed later [6-8]. The first version of the ${}^{147g}Tb$ decay scheme including 1153.0 keV, 1292.8 keV, 1412.5 keV, 1700.2 keV, and 1847.5 keV levels of ${}^{147}Gd$ was proposed by Afanasiev *et al.* [9]. Then, studying the β-decay of both isomers, Newman *et al.* [10,11] observed one new low-spin state at 1759.1 keV and several high-spin states of ^{147}Gd. Futher investigations of the ${}^{147}Gd$ level structure were carried out using mostly nuclear reactions and led to substantial increase in the data on high-spin states [2],[12-17].

Piiparinen *et al.* [18] investigated the decay scheme of the high spin ^{147}Tb isomer. The number of low-spin states observed at the ${}^{147g}Tb$ β-decay remained unchanged. In papers [17,19-22] intensities and multipolarities of the γ-transitions in this decay were defined. Spins and parities of the levels were established. New data on the β-decay of ${}^{147}Tb$ were reported by Manegazzo *et al.*[23]. Veselov *et al.* [24] measured end point energies of positron spectra at the decay of ^{147g}Tb in coincidences with 1152 keV and 694 keV γ-rays and obtained $Q_{EC}(^{147g}Tb)$=5250(150) keV. Considering the 50.6 keV energy of the isomeric state ^{147m}Tb established by Liang *et al.* [8] this value is in contradiction with known Q_{EC} for ^{147m}Tb: 4600($^{+150}_{-110}$) keV [25], 4620(60) keV [26], 4650(60) keV [27] and 4660(15) keV [28]. The cause of this contradiction will be cleared up below.

In order to obtain more ample data on low-spin states of ^{147}Gd we have studied the β-decay of ^{147g}Tb ($1/2^+$, 1.6 h). Using sources of ^{147g}Tb made by the off-line technology we carefully investigated γ-rays, internal conversion electrons, and $\gamma-\gamma$-coincidence spectra. Many new high lying low-spin states of ^{147}Gd were proposed and discussed. Preliminary results of these investigations were reported in [29,30].

2. Experimental results

The ^{147g}Tb (1.6 h) sources were produced by spallation of tantalum in the internal beam of 660 MeV protons from the JINR phasotron in Dubna. Approximately 0.5 h after the irradiation the tantalum target was dissolved and the terbium fraction was separated without carrier on the chromatographic microcolumn. ^{147}Tb was separated from other terbium isotopes on the electromagnetic mass separator of the ISOL-facility YASNAPP-2 [31]. Tb ions were collected on an Al-foil. The sources obtained contained ^{147g}Tb (1.6 h) and daughter ^{147}Gd (38 h) and ^{147}Eu (24 d). Admixtures of neighbouring long-lived terbium isotopes were less than 1%.

Measurements of γ-ray spectra were carried out using two Ge(Li)-detectors (85 cc and 100 cc, FWHM equal 1.9 and 2.8 keV at 1.33 MeV) and HPGe-detector (2 cc), FWHM equal 1.2 keV at 120 keV). To avoid summing of pulses from the cascade γ-quanta we used filters of 1mm Cd+4mm Pb for absorption of intense 120 keV and 140 keV γ-rays in measurements of the high-energy ($E_\gamma > 0.5 MeV$) part of the γ-spectrum and of 1 mm Cd for the low-energy measurements. The source-detector distance was 3-5 cm. The measurement time of one source was less than three half-lives of ^{147g}Tb. The high-energy part of the γ-spectrum measured by the 85 cc Ge(Li) detector is shown in Fig.1. Note the high

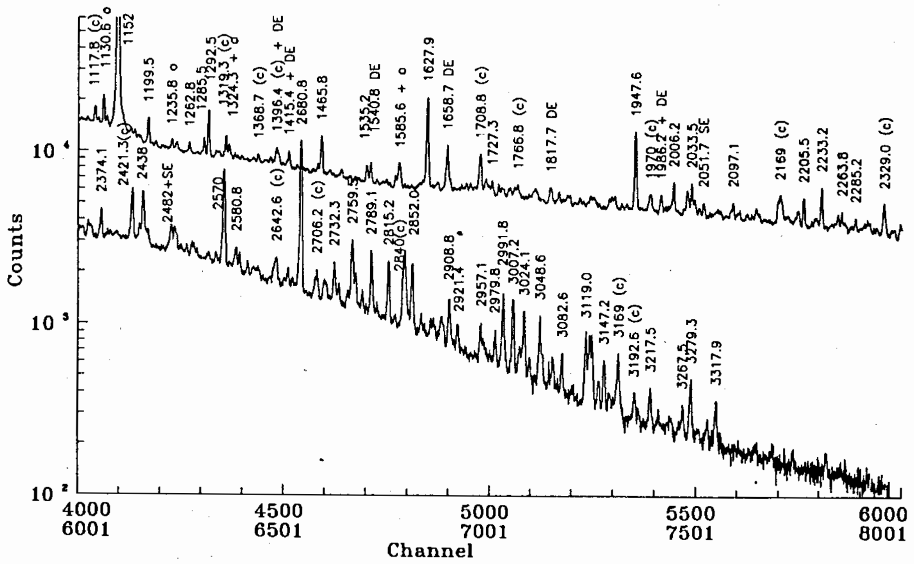

Fig.1. High-energy part of the γ-ray spectrum of ^{147g}Tb (1.64h):
o - ^{147}Gd - photopeaks of the daughter ^{147}Gd nucleus.
(c) - complex peaks.
(DE) and (SE) - double and single escape peaks.

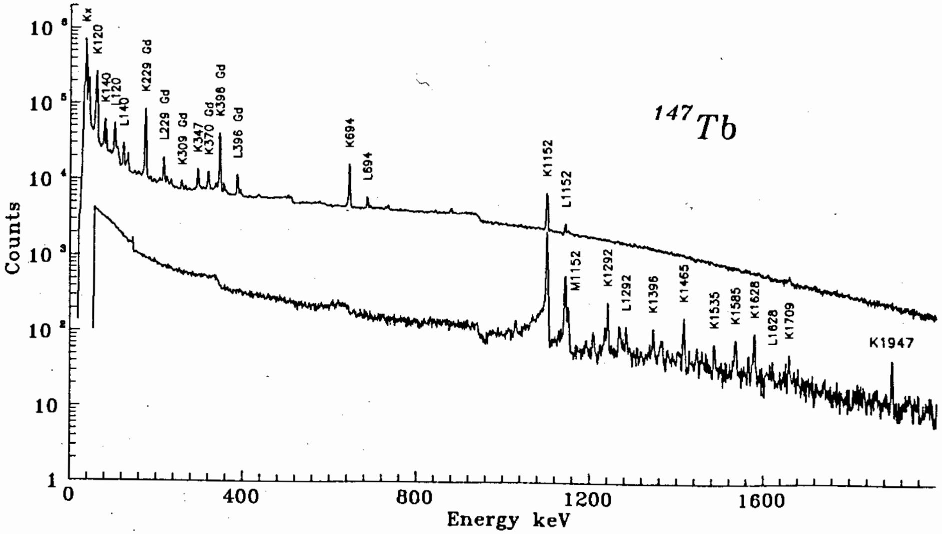

Fig.2. Spectra of the internal conversion electrons at the decay of ^{147g}Tb, measured with a miniorange magnetic filter (bottom) and without it (top).

density of weak γ-lines over the whole spectrum up to 3.5 MeV. Observing the decay of the most intense peaks in the γ-ray spectra we measured the ^{147g}Tb half-life. The value obtained is $T_{1/2} = (1.64 \pm 0.03)h$.

All spectra were analysed using the program KATOK [32] adapted to a PC IBM AT. In some cases $\gamma-\gamma$-coincidence spectra were used to establish a double structure of γ-peaks. Energy values for 25 intense peaks in the γ-ray spectrum were determined in experiments where detectors were additionally "lighted" by γ-rays from ^{182}Ta and ^{56}Co sources. These values were then used for the inner correction of the energy scale of the spectrometers. The energy and relative intensity (down to $J_\gamma \geq 0.1\% J_\gamma$ (1152)) values obtained are presented in Table 1. The errors include both statistical errors and errors of the energy and efficiency calibrations. The comparison of the data from Table 1 with the ones from papers [9-11,19] shows that only the most intense γ-transitions were earlier obserwed. Of 128-γ-transitions listed in Table 1 115 are new. About 20 of these new transitions were shown in the decay scheme of ^{147g}Tb published in a short report by Menegazzo *et al.* [23].

The internal conversion electron spectrum of ^{147g}Tb was measured using a Si(Li)-detector ($3mm \times 300mm^2$) without and with a mini-orange magnetic filter [30]. For the efficiency calibration the ^{166}Tm, ^{152}Tb and ^{207}Bi sources and daughter ^{147}Gd were used. The mini-orange allows the spectrum to be purified of positrons. It was especially important in the high energy part of the spectrum shown in Fig.2. The data on the intensity of K- and L-conversion lines, deduced α_K-values and multipolarities (Fig.3) of γ-transitions are given in Table 2. The character of the γ-transitions with energy 554.6 keV and above 1152 keV was established for the first time. Other data confirmed conclusions made in previous papers [34].

Spectra of γ-γ-coincidences were studied on a three-dimensional EET-spectrometer consisting of two Ge(Li) - detectors (85 and 100 cc in volume)and a coincidence selection system based on the digital window principle and constructed in the CAMAC standard [35]. In order to place new, first of all weak high-energy γ-transitions in the ^{147}Gd level scheme $\gamma-\gamma$-coincidence spectra were measured in energy windows placed on the photopeaks of the 120, 140, 347, 407, 546, 694, and 1152 keV γ-transitions depopulating the known excited states and on the photopeaks of most intense 1628 and 1947 keV new γ-transitions . For each window there was a corresponding additional window placed just behind the photopeak of

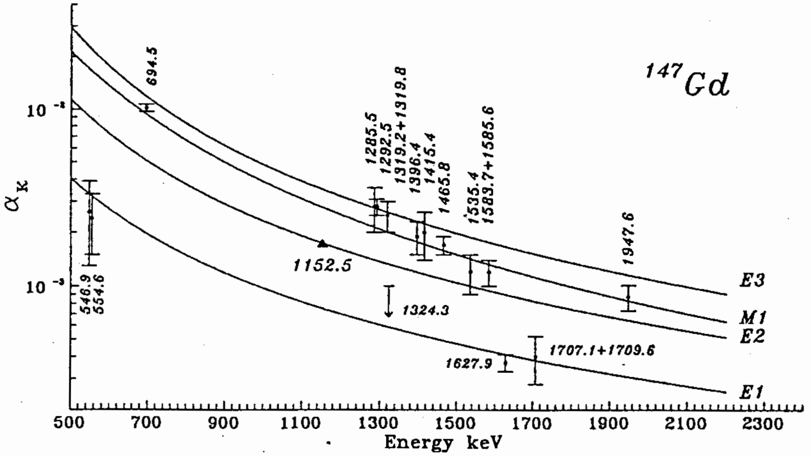

Fig.3. Comparison of the measured α_k values with the calculated ones.

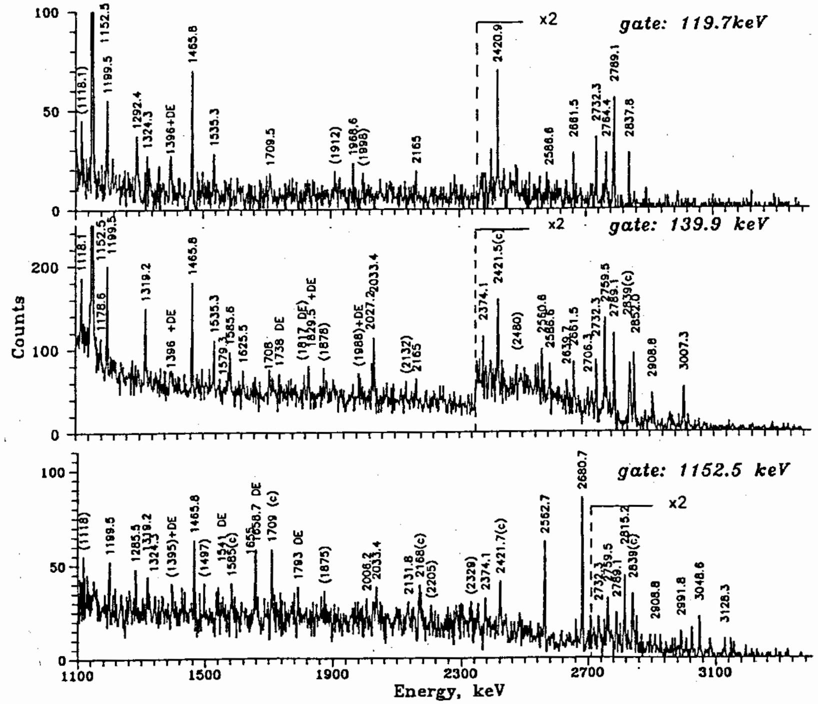

Fig.4. Spectra of the γ-γ-coincidence at the ^{147g}Tb decay. The γ-gates are marked in the upper right corner of every picture.

the above-mentioned γ-rays. Coincidence spectra in the energy range up to 3350 keV were registered with the 100 cc Ge(Li)-detector with a 1 mm Cd+4 mm Pb+1 mm Cd Filter. The radioactive sources were placed between the detectors arranged at an angle of 180°. The time window was 50 ns. Some of the coincidence spectra obtained in one of the two independent experiments are shown on Fig. 4(a-d). Windows where the corresponding γ-rays were observed are given in the third column of Table 1. Note that the majority of the γ-rays observed in the single γ-spectrum were found in coincidence spectra.

The β-decay energy Q_{EC} *for* ^{147g}Tb measurement aimed to clear up a contradiction between the data of [24] and [25-28] was carried out by two methods. Measurements of the positron spectrum end point energies were repeated using the 9 mm thick HPGe detector for positron detection in coincidences with γ-rays [36]. Only ($\gamma694 - \beta^+$) coincidences were of use for $E_{\beta^+ max}$ determination. A large number of cascade γ-quanta observed in this inverstigation greatly distort the spectra measured by the HPGe detector and exclude the possibility of using coincidences with 1152 keV, 120 keV and 140 keV γ-quanta. This also caused overestimation of Q_{EC} in [24]. The value obtained in our measurements is Q_{EC}=4580(100) keV. Q_{EC} for ^{147g}Tb was also measured by the full γ-ray absorption method [37]. The spectrometer employed [38] consists of two NaI(Tl) scintillators 210 mm × 140 mm and 160 mm x 110 mm in size and a Si(Li) detector placed together with a source in the well of the large scintillator. The Q_{EC} measured is 4510(70) keV. Thus Q_{EC} measured do not contradict Q_{EC} deduced from [25-28]. Determining logft below we take the most precise value Q_{EC}=4605(15) keV calculated with the data of Keller *et al.* [28] and Liang *et al.* [8].

3. The decay scheme of ^{147g}Tb

On the basis of our results and the data from previous papers it is possible to construct a new, more complete scheme of the ^{147g}Tb β-decay including 44 excited states of ^{147}Gd and 105 γ-transitions placed between them (Table 3, and Fig. 5 a,b). The placement of γ-transitions is also given in Table 1. All excited states above 1847.1 keV are new ones introduced in this work. Some of them were proposed in the report by Manegazzo et al. [23]. Most of the levels are established on the basis of $\gamma - \gamma$-coincidences. So levels with energy 2878.0. 3833.3. 3853.2. 3891.7. 4073.7. 4144.4. and 4201.2 keV are confirmed by three or more pairs of coincident γ-rays. The 2438.0. 2611.7. 2736.3. 2808.4. 2871.6. 2947.4. 3121.8. 3171.5. 3319.6. 3325.8. 3574.0. 3715.4. 3998.7. 4051.9, 4132.3. 4176.6. 4280.4. and 4229.7 keV levels were established on the basis of two pairs of coincident γ-rays. And the 2862.0. 3926.0. 3967.7. 4929.7. and 4369.8 keV levels are introduced on the basis of one pair of coincident γ-transitions. The nonobservation of rather intense 1947.6. 2233.2, 2329.0. 3119.0. and 3124.2 keV γ-rays in the $\gamma - \gamma$-coincidence spectra became an argument for the introduction of levels of these energies. In the case of the 1947.6 keV level the 2197.0 keV γ-transition populating this level was observed in $\gamma - \gamma$-coincidences.

Below the 1847.1 keV state we introduced only one level at 1627.9 keV ($J^\pi = 5/2^+$). Four γ-rays populating this level were observed in $\gamma - \gamma$-coincidences (Fig.5). The $J^\pi = 7/2^+$ state with almost the same energy (1628.3 keV) was found in ($^3He,3n$) and (α,n)-reactions [17]. E1 multipolarity of the 1627.9 keV γ-transition and two γ-transitions populating the 1627.9 keV level from the states with most probable I=1/2 allow us to ascribe $I^\pi = 5/2^+$ to the 1627.9 keV level.

The total intensity of γ-rays not placed in the proposed decay scheme is less than 4% of J_γ 1152 taken in Table 1 for 100. The analysis of the integral $\gamma - \gamma$-coincidence spectrum allows us to suggest that about one half of this intensity is connected with γ-transitions to the ground state of ^{147}Gd. Thus summing up the intensities of transitions populating the ^{147}Gd ground state we can find the full intensity of the ^{147g}Tb (EC+β^+) decay. In units of Table 1 it is equal to 111(3). Its distribution over the excited states of ^{147}Gd and the corresponding logft values are given in Table 3 and in Fig.5. The value $T_{1/2}$=1.64(3) h measured in this work and Q_{EC}=4605(15) keV [28,8] were used for logft calculations.

Spin 7/2 for the ^{147}Gd ground state was established in [39]. It is reasonable to identify it with the $2f_{7/2}$ state of the shell model and ascribe $J^\pi = 7/2^-$ to it. It is also reasonable to identify the long-lived isomer of ^{147}Tb with the $3s_{1/2}$ shell model state and ascribe $J^\pi = 1/2^+$ to it. Spins and parities of the formerly known low energy states of ^{147}Gd were established in [17,19-21]: 1152.5 keV ($3/2^-$). 1292.4 keV ($1/2^+$). 1412.2 keV ($3/2^+$). 1699.5 keV ($3/2^+$). 1759.8 ($1/2^+$). and 1847.1 keV ($1/2^-$). They are adopted in this work as a basis. Spins and parities of the states presented in Fig.5 are inferred from the transition multipolarities. logft values and modes of level population and depopulation. For example. I=1/2 ascribed to the 3833.3. 4144.4. 4201.2. 4299.7. and 4431.4 keV states because these levels have logft=5.6÷5.9.

4. Discussion. Structure of the ^{147}Gd low-spin states

Assuming $^{147}_{64}Gd_{83}$ nucleus to be a system composed of a strongly bound even-even core of double-magic $^{146}_{64}Gd_{82}$ and a single valence neutron we state that in the framework of the spherical shell model the spectrum of excited states in the range of energies accessible in the β-decay of ^{147}Tb (E < 4.5 MeV) is determined by

- one neutron states of the 82< N<126 shell;
- neutron-hole excitations with the formation of an external neutron pair in the state $J^{\pi} = 0^{+}$. i.e two-quasiparticle - one-hole (2p1h) excitations within the 50< N < 82 neutron shell;
- collective (quasiparticle-phonon) states. arising from coupling of the one-quasiparticle excitations of both types with the lowest excitations of the core;
- three quasiparticle states. including neutron-proton excitations.

From the analysis of β-transition probabilities, from both isomeric states of ^{147}Tb ($\pi s_{1/2}$ and $\pi h_{11/2}$) and from the systematics of one-particle states in odd N=83, Z<64 isotopes, for which there is data from single nucleon transfer reactions, the authors of Ref. [17,19,20] conclude that levels 0 keV. 1152.5 keV, 1387.3 keV, and 1847.1 keV are single particle states $\nu 2f_{7/2}$. $\nu 3p_{3/2}$. $\nu 1h_{9/2}$, and $\nu 3p_{1/2}$ respectively, with possible admixture of other configurations. One particle $\nu 2f_{5/2}$ and $\nu 1i_{13/2}$ excitations supplementing the 82< N< 126 shell were not found in ^{147}Gd.

According to [40], the analysis of the energies of two- particle states $(\nu f_{7/2}i_{13/2})_{10^-}$ in even-even isotopes with N=84 and three-particle states $(\nu f_{7/2}i_{13/2})_{25/2^+}$ in odd N=85 isotones suggests that the energy of the unperturbed one-particle $\nu i_{13/2}$ state in ^{147}Gd should be 2.1(1) MeV. Consideration of repulsive interaction with the close lying $(\nu f_{7/2}\mathrm{x}3^{-})_{13/2^+}$ state leads to a strong mixing of these configurations [41-43] and to appreciable shift of their energies. According to the estimates [21,40] the energy of the ^{147}Gd state with the dominant one-particle $\nu i_{13/2}$ component is about 2.5 MeV. A perturbed state $(\nu f_{7/2}\mathrm{x}3)_{13/2^+}$ is observed experimentally at 997.2 keV [10].

The real structure of the $\nu f_{5/2}$ state in ^{147}Gd is also complex because the $(\nu f_{7/2}\mathrm{x}2^{+})_{5/2^-}$ state is located close to it. Both of them are expected to be the lowest lying ones with $I^{\pi}=5/2^{-}$ and, naturally, they are coupled to the ground $\nu f_{7/2}$ state by strong γ-transitions. The good candidates for such interpretation are the new levels with energies 1947.6 keV and 2233.2 keV. Indicative of this are their energies, probable spin and parity values, deexcitation modes and also the systematics of one-particle states with negative parity in odd-A N=83 isotones shown in Fig.6. Note that according to our preliminary calculations of the spectrum of one particle states in the Saxon-Woods potential the energy of the $\nu 2f_{5/2}$ state in ^{147}Gd is expected to be 100-150 keV higher than that of the $\nu s_{1/2}$ state (1847.1 keV),i.e. close to the 1947.6 keV level.

Comparing the energy intervals between the one-hole $\nu s^{-1}_{1/2}$ (0.0 keV) and $\nu 2d^{-1}_{3/2}$ (27 keV) levels and the 1p2h, $\nu 2f_{7/2}j^{2}_{0}$ (1273 keV) level in ^{145}Gd nucleus and between the lowest states in ^{147}Gd, Komppa *et al.* [17] and Styczen *et al.* [19] come to the conclusion that $1/2^{+}$; 1292.4 keV and $3/2^{+}$; 1412.2 keV levels in ^{147}Gd are the lowest 1h2p excitations of $\nu s^{-1}_{1/2}{}^{+}j^{2}_{0}$ and $\nu d^{-1}_{3/2}j^{2}_{0}$ types, respectively. However the results of Kader et al. [21], where spectroscopic factors of the (d,t) reaction for four lowest ^{147}Gd levels were measured, unambiguously indicate that the 1292.4 keV and 1412.2 keV levels should be regarded as members of the $(\nu f_{7/2}\mathrm{x}3^{-})$ multiplet with a small admixture of the hole configurations $\nu s^{-1}_{1/2}j^{2}_{0}$ and $\nu d^{-1}_{3/2}j^{2}_{0}$ and these configurations must be ascribed to the 1759.8 keV ($1/2^{+}$) and 1699.5 keV ($3/2^{+}$) levels. A new argument in favour of ascribing the dominant component $(\nu f_{7/2}\mathrm{x}3^{-})_{1/2^+}$ to the 1292.4 keV state is the existence of the relatively strong E3 transition deexciting this level directly to the ground state.

The interaction of the lowest core excitation (E_{3^-}=1579 keV) with one-particle states of the 83th neutron from the 82 < N < 126 shell generates in ^{147}Gd 26 excited states of positive parity with I< 15/2 and E < 3.6 MeV, among them 11 low spin states with I < 5/2. Many aufhors looked for states of the lowest $(\nu f_{7/2}\mathrm{x}3^{-})(I^{\pi} = 1/2^{+} - 13/2^{+})$ multiplet. After assumption that the $1/2^{+}$, 1292.4 keV and $3/2^{+}$, 1412.2 keV levels belong to this multiplet, all remaining members of it were identified [21], except $I^{\pi} = 5/2^{+}$ ones. We believe that the new 1627.9 keV level found in this work is this missing state. It follows not only from its energy and

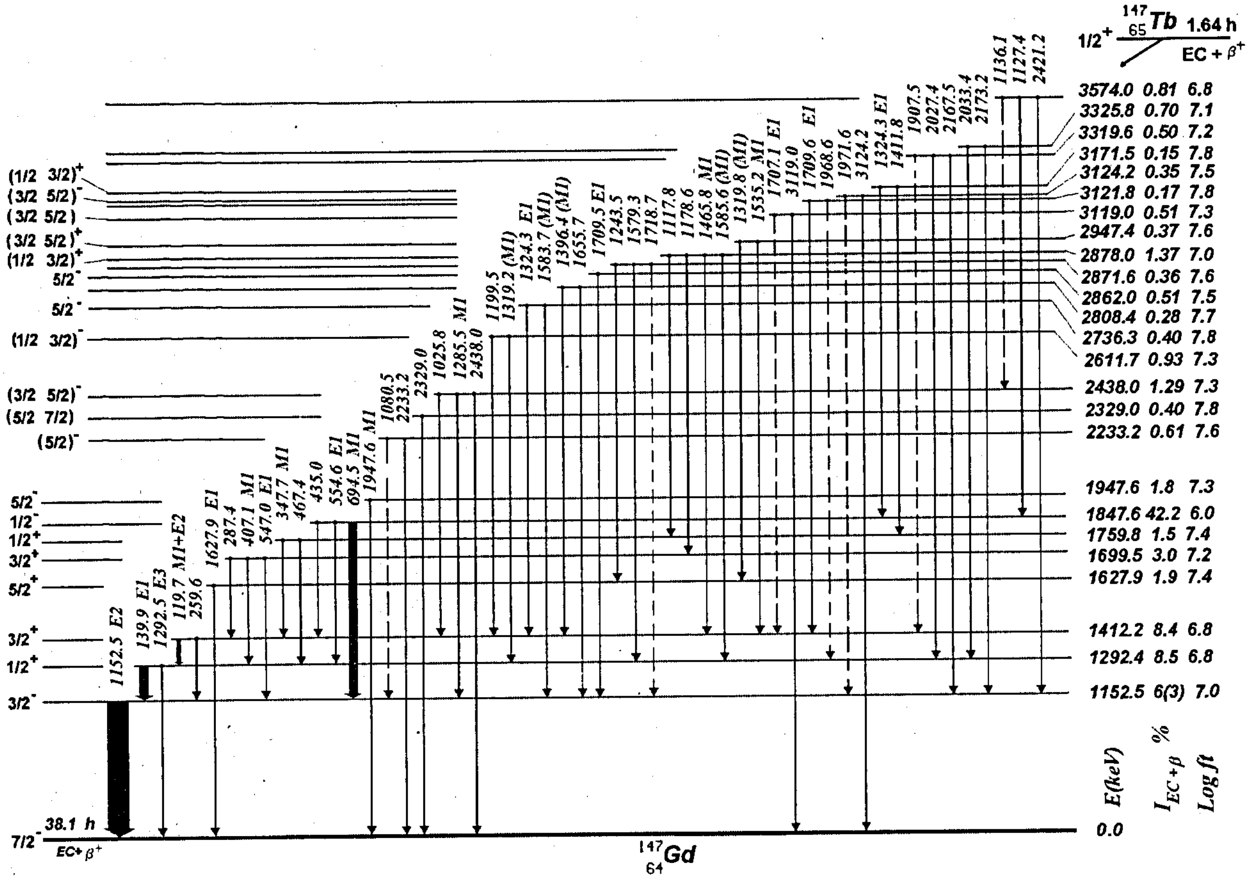

Fig.5a.

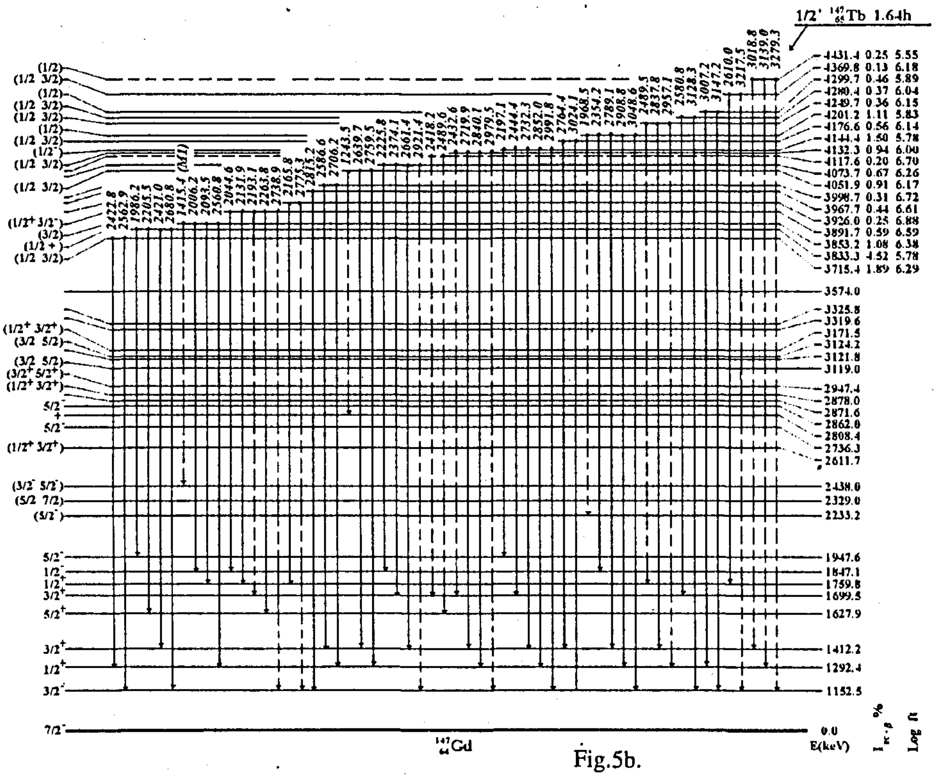

Fig.5b.

The proposed ^{147g}Tb decay scheme. The solid lines corresponds to the γ-transitions placed on the basis of the $\gamma-\gamma$-coincidence results. The dash line - γ-transitions placed only on the basis of the energy relations.
a) low energy levels of ^{147}Gd; b) High energy levels of ^{147}Gd.

$I^{\pi} = 5/2^{+}$, but also from the mode of its deexcitation via a γ-transition only to the ground state.

The structure of the positive parity states belonging to other particle-octupole configurations in ^{147}Gd is rather complex. Their energies are expected to be above 2.3 MeV, where numerous intermixing states of the same parity of other configurations can also be present, and among them these of the $(\nu^{-1}_{1/2}\mathrm{x}2^{+})$, $(\nu d^{-1}_{3/2}\mathrm{x}2^{+})$, and $(\nu f_{7/2}\mathrm{x}5^{-})$ multiplets.

The lowest particle-phonon states of negative parity in the ^{147}Gd nucleus related to the quadroupole core excitations (E_2+=1972 keV) belong to the $(\nu f_{7/2}\mathrm{x}2^{+})$ $(I^{\pi} = 3/2^{-} - 11/2^{-})$ multiplet. The interaction with low-lying one particle states of negative parity leads to some modification of their structure and to energy shifts. The first high spin members of this multiplet, I^{π}=11/2^{-}; 1944 keV and 9/2^{-}; 1798 keV, with a considerable admixture of one particle component (ν $h_{9/2}$), were identified in Refs.[17,18]. Its low spin members can be among the new levels observed by us in the energy range 1.9-2.5 MeV. Above, when discussing one-particle excitations, we have already assumed that the $(\nu\ f_{7/2}\mathrm{x}2^{+})_{5/2}$ state strongly mixed with the $(\nu f_{5/2})$ state can be identified with the 2233.2 keV level.

In the 3.0-4.4 MeV energy range of the spectrum low spin states of ^{147}Gd we found 26 levels. The majority of them are grouped above 3.8 MeV and have distinctly low values of logft=5.8 ÷ 6.6, as compared with the majority of lower lying states, for which logft>6.8 are observed. To find a simple explanation of this fact it is necessary to assume that the main configurations of this group of excitations are other than quasiparticle-phonon ones characterized by logft > 6.8. Naturally, one should consider first of all three-quasiparticle configurations, and among them those which enable the ^{147g}Tb nucleus to undergo fast (allowed) β-decay like GT-transitions related to the proton pair decay $(\pi\ h^{2}_{11/2})_{0+} \rightarrow (\pi\ h_{11/2}\nu_{9/2})_{1+}$.

5. Conclusion

The study of γ-ray, internal conversion electron and $\gamma-\gamma$- coincidence spectra at the β-decay of the ^{147}Tb $\pi\ 3s_{1/2}$ isomeric state allows extensive new data on properties of low spin states of ^{147}Gd. Intensities of all γ-rays with $J_{\gamma} > 0.06\%$ ^{147g}Tb are measured. Multipolarities of number of γ-

Table 1. Gamma transitions in ^{147}Gd observed in the β-decay of ^{147g}Tb and summary of $\gamma-\gamma$-coincidence data.

Energy (keV)	*Intensity*	*Coincides with gates*$^{a)}$	*Placement* $E_i - E_f(keV)$
119.74(3)	7.5(2)	140,348,1152	1412.2 - 1292.4
139.89(3)	34.1(9)	120,348,407,1152	1292.4 - 1152.5
259.6(1)	≤0.4	348,1152	1412.2 - 1152.5
287.4(1)	0.19(6)	120,140	1699.5 - 1412.2
347.65(3)	2.63(6)	120,140,1152	1759.8 - 1412.2
407.06(3)	1.95(7)	140,1152	1699.5 - 1292.4
434.96(4)	0.68(5)	120,140,1152	1847.1 - 1412.2
467.4(1)	0.14(7)$^{b)}$	140	1759.8 - 1292.4
546.96(3)	2.19(6)	1152	1699.5 - 1152.5
554.65(3)	5.75(13)	140,1152	1847.1 - 1292.4
694.54(3)	41.4(9)	1152	1847.1 - 1152.5
1025.8(1)$^{c)}$	0.38(3)	120	2438.0 - 1412.2
1080.5(3)	0.06(4)		(2233.2 - 1152.5)
1117.8(3)$^{c)}$	0.43(4)	120,140,348,1152	2878.0 - 1759.8$^{p)}$
1136.1(3)$^{c)}$	0.16(3)?		(3574.0 - 2438.0)
1152.53(3)	≡100.0(25)	120,140,348,407,694	1152.5 - 0,0
1178.6(3)	0.11(2)	140,407	2878.0 - 1699.5
1199.53(6)	0.66(3)	120,140,1152	2611.7 - 1412.2
1243.5(4)$^{c)}$	0.20(3)	1628	2871.6 - 1627.9$^{p)}$ (4051.9 - 2808.3)
1262.8(2)	0.17(3)		
1285.45(7)	0.36(2)	1152	2438.0 - 1152.5
1292.51(7)	1.25(5)	120,348,407	1292.4 - 0.0
1319.2(1)$^{b)}$	0.38(5)	140,1152	2611.7 - 1292.4
1319.8(3)$^{b)}$	0.14(3)	1628	2947.4 - 1627.9
1324.3(2)	0.18(3)	120,140,694,(1152)	2736.4 - 1412.4 3171.5 - 1847.1
1368.7(2)$^{c)}$	0.14(2)	(1628)	
1396.4(4)$^{c)}$	0.32(3)	120,140,(1152)	2808.4 - 1412.2$^{p)}$
1411.8(3)	0.07(3)		(3171.5 - 1759.8)
1415.4(4)	0.20(3)		(3853.2 - 2438.0)
1465.75(7)	0.82(4)	120,140,1152	2878.0 - 1412.2
1535.2(1)	0.34(2)	120,140,(1152)	2947.4 - 1412.2$^{p)}$
1579.2(1)	0.19(3)	140	2871.6 - 1292.4
1583.7(2)	0.29(4)	1152	2736.4 - 1152.5
1585.6(1)	0.30(4)	140,(407),1152	2878.0 - 1292.4
1625.3(4)	0.31(4)	(1948)	(3574.0 - 1947.1)
1627.91(6)	3.14(12)		1627.9 - 0.0
1655.7(2)	0.21(2)	1152	2808.4 - 1152.5
1707.1(2)	0.30(4)	(120,140,1152)	3119.0 - 1412.2

Table 1. *continued*

Energy (keV)	*Intensity*	*Coincides with gates*$^{a)}$	*Placement* $E_i - E_f(keV)$
1709.6(1)	0.14(4)$^{b)}$	120,140	3121.7 - 1412.2
	0.57(7)	1152	2862.0 - 1152.5
1718.5(3)$^{c)}$	0.17(3)	(1152)	2871.6 - 1152.5$^{r)}$
1727.4(3)	0.14(3)	694	(3574.0 - 1847.1)
1907.5(4)	0.14(3)		(3319.6 - 1412.2)
1912.6(4)	0.06(4)	(120)	
1916.3(3)	0.20(3)		
1947.58(6)	2.19(6)	(1628)	1947.6 - 0.0
1968.5(3)	0.10(4)		(3121.7 - 1152.5)
			(4201.2 - 2233.2)
1971.6(5)	0.16(4)		(3124.2 - 1152.5)
1986.2(1)	0.15(3)	694	3833.3 - 1847.1
2006.15(8)	0.49(2)	694,1152	3853.2 - 1847.1
2021.5(3)	0.10(3)		
2027.4(3)$^{c)}$	0.37(3)	140,1152	3319.6 - 1292.4$^{r)}$
2033.45(8)	0.60(4)	140,1152	3325.8 - 1292.4
2038.4(2)$^{c)}$	0.18(3)		
2044.6(4)	0.09(2)	(694)	3891.7 - 1847.1
2093.5(3)	0.13(3)	348	3853.2 - 1759.8
2131.9(3)	0.20(2)	(140),348,1152	3891.7 - 1759.8
2165.8(3)	0.16(4)$^{b)}$	120,140,348,1152	3926.0 - 1759.8
2167.5(5)	0.15(5)	(1152)	3319.6 - 1152.5
2173.2(4)	0.18(3)	1152	3325.8 - 1152.5
2193.1(4)	0.08(2)	(407)	(3891.7 - 1699.5)
2197.1(2)	0.21(2)	1948	4144.4 - 1947.6
2205.54(7)	0.50(2)	1628,(1152)	3833.3 - 1627.9
2225.8(3)	0.09(2)	694	4073.7 - 1847.1
2233.17(4)	0.72(3)		2233.2 - 0.0
2258.3(2)	0.09(3)		
2263.8(3)	0.15(2)	1628	3891.7 - 1627.9
2329.0(1)$^{c)}$	0.12(6)$^{b)}$	(1152)	
	0.45(7)		2329.0 - 0.0
2354.2(2)	0.12(3)	694	4201.2 - 1847.1
2374.1(1)	0.39(4)	140,407,1152	4073.7 - 1699.5
2418.2(3)	0.11(3)	(407)	(4117.6 - 1699.5)
2421.0(4)$^{b)}$	0.48(6)$^{b)}$	120,140,1152	3833.3 - 1412.2
	0.6(2)$^{b)}$		3574.0 - 1152.5
2422.8(2)	0.14(9)$^{b)}$	140,1152	3715.2 - 1292.4
2432.6(2)	0.21(2)		(4132.3 - 1699.5)
2438.02(6)	1.06(4)		2438.0 - 0.0

Table 1. *continued*

Energy (keV)	*Intensity*	*Coincides with gates*$^{a)}$	*Placement* $E_i - E_f(keV)$
2444.4(9)$^{c)}$	0.30(5)	(407)	4144.4 - 1699.5$^{r)}$
2481.6(1)	0.26(3)		
2486.5(3)	0.29(3)		
2489.6(2)	0.22(3)	(140,348,1152,1628)	(4249.7 - 1759.8)
			(4117.6 - 1627.9)
2560.8(2)	0.38(6)	140,1152	3853.2 - 1292.4
2562.9(1)	1.96(10)	1152	3715.2 - 1152.5
2580.8(1)	0.20(3)	407	4280.4 - 1699.5
2586.6(1)	0.15(3)	120,140	3998.7 - 1412.2
2610.0(5)	0.06(2)	(348)	4369.8 - 1759.8
2639.7(4)	0.13(2)	140	4051.9 - 1412.2
2643.0(2)	0.25(3)		
2661.4(2)	0.14(2)	120,140,1151	4073.7 - 1412.2
2680.77(6)	3.90(12)	(407),1152	2833.3 - 1152.5
2702.1(3)	0.12(2)		
2706.2(2)	0.20(2)	140,1152	3998.7 - 1292.4
2716.5(3)	0.13(2)		
2719.9(2)	0.11(2)	120,140	4132.3 - 1412.2
2732.3(1)	0.35(2)	120,140,1152	4144.4 - 1412.2
2738.9(2)	0.14(2)		(3891.6 - 1152.5)
2759.45(8)	0.79(3)	120,140	4051.9 - 1292.4
2764.4(1)	0.26(3)	120,140,1152	4176.6 - 1412.2
2775.3(2)	0.12(2)	1152	3926.0 - 1152.5
2789.08(8)	0.54(3)	120,140,1152	4201.2 - 1412.2
2815.19(8)	0.49(2)	1152	3967.7 - 1152.5
2837.8(3)	0.26(4)	120,140,1152	4249.7 - 1412.2
2840.1(2)	0.60(6)	140,1152	4132.3 - 1292.4
2852.00(8)	0.55(3)	140,1152	4144.4 - 1292.4
2865.6(3)	0.08(2)		
2896.6(4)$^{c)}$	0.14(3)		
2908.8(1)	0.29(2)	140,1152	4201.2 - 1292.4
2921.4(2)	0.13(3)		(4073.7 - 1152.5)
2957.1(2)	0.14(3)	140	4249.7 - 1292.4
2961.5(2)	0.06(2)		
2979.5(2)	0.13(2)		(4132.3 - 1152.5)
2991.8(1)	0.41(3)	1152	4144.4 - 1152.5
3007.2(1)	0.38(3)	140,1152	4299.7 - 1292.4
3018.8(4)$^{c)}$	0.11(2)	(140)	(4431.4)- 1412.2
3024.1(1)	0.36(2)	1152	4176.6 - 1152.5

Table 1. *continued*

Energy (keV)	*Intensity*	*Coincides with gates*$^{a)}$	*Placement* $E_i - E_f$*(keV)*
3048.6(1)	0.25(1)	1152	4201.2 - 1152.5
3052.3(3)	0.08(1)	(120)	4464.7 - 1412.2
3068.3(2)	0.10(2)		
3082.6(3)$^{c)}$	0.12(2)	(1152)	
3119.0(2)	0.27(1)		3119.0 - 0.0
3124.5(3)	0.23(2)		3124.1 - 0.0
3128.3(4)	0.21(2)	1152	4280.4 - 1152.5
3139.0(3)	0.06(1)		(4431.4 - 1292.4)
3147.2(2)	0.13(2)	1152	4299.7 - 1152.5
3169.0(4)$^{c)}$	0.16(3)		
3192.6(4)$^{c)}$	0.06(2)		
3217.5(4)	0.08(2)		(4369.8 - 1152.5)
3267.5(3)	0.06(1)		
3279.4(2)	0.14(2)		(4431.4 - 1152.5)
3304.7(3)	0.022(8)		
3317.9(2)	0.09(1)		

a) See the text.

b) From coincidence spectra.

c) Complex line in the γ-spectrum.

p) Part of presented intensity.

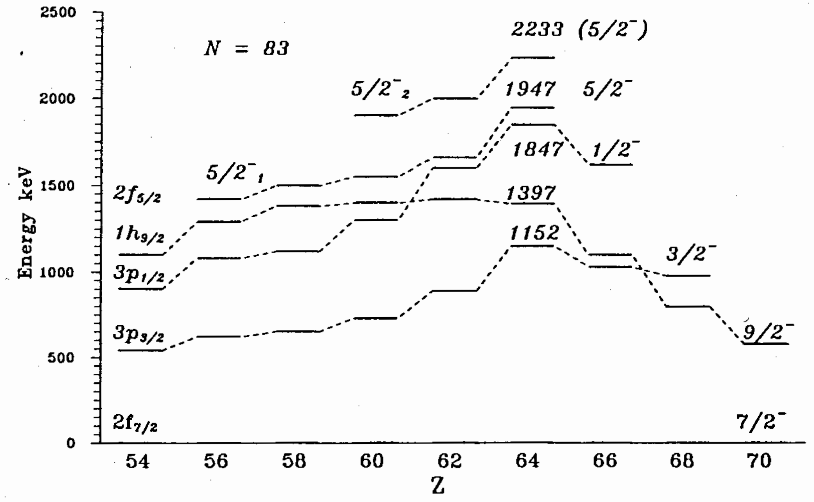

Fig.6. Systematics of the odd parity states in the even Z, N=83 isotopes.

Table 2. Intensities of some K-(and L-) conversion lines, respective conversion coefficients, and multipolarities of the γ-transitions in the^{147g}Tb decay.

$E_\gamma^{a)}$(keV)	$I_\gamma^{a)}$	$I_e^{b)}$	α_K and α_L	$\sigma L^{d)}$
119.7	7.5(2)	K 7.7(1)	1.01(6)	M1
		L 1.37(3)	0.18(1)	
139.9	34.1(9)	K 3.38(6)	0.099(4)	E1
		L 0.49(2)	0.015(1)	
347.7	2.63(6)	K 0.14(1)	0.053(4)	M1
407.1	1.95(7)	K 0.069(8)	0.035(4)	M1
547.0	2.19(6)	K 0.006(3)	0.0026(13)	E1
554.7	5.75(13)	K 0.014(5)	0.0024(9)	E1
694.5	41.4(9)	K 0.421(6)	0.0102(5)	M1
		L 0.056(6)	0.0014(2)	
1152.5	100.0(25)	K 0.173(4)	≡0.00173(6)	≡ E2
		L 0.024(4)	0.00024(5)	
1285.5	0.36(2)	K 0.0010(3)	0.0028(8)	M1,(E3)
1292.5	1.25(5)	K 0.0035(3)	0.0028(3)	E3
1319.2	0.38(5)			M1
		}K 0.0013(2)	0.0025(5)	
1319.8	0.14(3)			(M1)
1324.3	0.18(3)	K 0.00018(15)	0.0010(8)	E1
1396.4$^{c)}$	0.32(3)	K 0.0006(1)	0.0019(4)	(M1)
1415.4	0.20(3)	K 0.0004(1)	0.0020(6)	(M1)
1465.8	0.82(4)	K 0.0014(1)	0.0017(2)	M1
1535.2	0.34(2)	K 0.0004(1)	0.0012(3)	M1,E2
1583.7	0.29(4)			(M1)
		}K 0.0007(1)	0.0012(2)	
1585.6	0.30(4)			(M1)
1627.91	3.2(2)	K 0.0012(1)	0.00037(4)	E1
1707.1	0.30(4)			E1
		}K 0.0004(1)	0.00040(12)	
1709.6$^{c)}$	0.71(5)			E1
1947.6	2.19(6)	K 0.0019(3)	0.00087(14)	M1

a) From Table 1.

b) Intensities of ICE-line have been scaled to the γ-ray intensities by fixing the $\alpha_{K1152.5}$(E2)=0.00173.

c) Complex line.

d) See Fig. 3

Table 3. Properties of ^{147}Gd levels populated in ^{147g}Tb.

Level energy (keV)	Deexciting transitions: $E\gamma(keV), \sigma L, I_{tot}(\Delta I_{tot})^{a)}$	$I_{EC+\beta^+}$ %	Logft	I^{π}
0.00		0.00		$7/2^{-b)}$
1152.54(3)	1152.5 E2 100.2(2.5)	5.9(2.7)	7.0	$3/2^{-b)}$
1292.43(4)	1292.5 E3 1.25(6),139.9 E1 38(1)	8.6(1.3)	6.8	$1/2^{+b)}$
1412.17(5)	259.6$\leq$0.4, 119.7 M1+E2 16.9(6)	8.38(26)	6.84	$3/2^{+b)}$
1627.91(6)	1627.9 E1 3.14(12)	1.91(13)	7.37	$5/2^{+}$
1699.49(4)	547.0 E1 2.20(6), 407.1 M1 2.04(8) 287.4 0.22(7)	2.96(15)	7.15	$3/2^{+b)}$
1759.83(6)	467.4 0.14(7), 347.7 M1 2.80(7)	1.50(12)	7.43	$1/2^{+b)}$
1847.08(4)	694.5 M1 41.6(9), 554.6 E1 5.80(13), 435.0,0.68(5)	42.2(14)	5.96	$1/2^{-b)}$
1947.58(6)	1947.6 M1 2.19(6)	1.78(6)	7.31	$5/2^{-}$
2233.17(4)	2233.2 0.72(3), (1080.5 0.06(4))	0.61(6)	7.64	$(5/2^{-})$
2329.0(1)	2329.0 0.45(7)	0.40(6)	7.81	(5/2,7/2)
2438.03(6)	2438.0 1.06(4), 1285.5 M1 0.36(2), 1025.8 0.38(3)	1.29(8)	7.26	$(5/2,3/2)^{-}$
2611.68(8)	1319.2 (M1) 0.38(5), 1199.5 0.66(3)	0.93(6)	7.32	$(1/2,3/2)^{+}$
2736.3(2)	1583.7(M1) 0.29(4),1324.3 E1 0.18(3)	0.42(5)	7.61	$<5/2^{-}$
2808.4(3)	1655.7 0.21(2), 1396.4 (M1) (0.20(6))	0.28(8)	7.73	
2862.0(2)	1709.6 E1 0.57(7)	0.51(6)	7.47	$<5/2^{+}$
2871.6(2)	(1718.5 0.09(3)), 1579.2 0.19(3), 1243.5(0.12(5))	0.36(6)	7.61	
2878.00(8)	1585.6 (M1) 0.30(4), 1465.8 M1 0.82(4), 1178.6 0.11(2), 1117.8 0.3(1)	1.37(11)	7.04	$1/2,3/2^{+}$
2947.4(1)	1535.2 M1 0.34(2), 1319.8 (M1) 0.14(3)	0.37(6)	7.57	$(3/2,5/2)^{+}$
3119.0(2)	3119.0 0.27(1), (1707.1 E1 0.30(4))	0.51(5)	7.32	(3/2,5/2)
3121.8(2)	(1968.5 0.05(4)), 1709.6 E1 0.14(4)	0.17(6)	7.79	
3124.2(3)	3124.2 0.23(2), (1971.6 0.16(4))	0.35(5)	7.49	(3/2, 5/2)
3171.5(4)	1411.8 0.07(3), 1324.3 E1 0.10(5)	0.15(5)	7.83	$(1/2^{+},3/2^{+})$
3319.6(3)	2167.5 0.15(5), 2027.4 0.27(6), (1907.5 0.14(3))	0.50(9)	7.20	
3325.8(1)	2173.2 0.18(3), 2033.5 0.60(4)	0.70(5)	7.05	
3574.0(3)	2421.0 0.6(2), 1727.3 0.14(3), (1136.1 0.16(3))	0.81(18)	6.79	
3715.4(1)	2562.9 1.96(10), 2422.8 0.14(9)	1.89(14)	6.29	(1/2,3/2)
3833.3(1)	2680.8 3.90(12), 2421.0 0.48(6), 2205.5 0.50(2), 1986.2 0.15(3)	4.52(17)	5.78	$1/2^{+}$

Table 3. *continued*

Level energy (keV)	Deexciting transitions: $E\gamma(keV), \sigma L, I_{tot}(\Delta I_{tot})^{a)}$	$I_{EC+\beta^+}$ %	Logft	I^{π}
3853.2(1)	2560.8 0.38(6), 2093.5 0.13(3), 2006.2 0.49(2), (1415.4 (M1) 0.20(3))	1.08(8)	6.38	$(3/2)^{-}$
3891.7(2)	(2738.9 0.14(2)), 2263.8 0.15(2), (2193.1 0.08(2)),2131.9 0.20(2), 2044.6 0.09(2)	0.59(5)	6.59	$(1/2^{+},3/2^{-})$
3926.0(4)	(2775.3 0.12(2)), 2165.8 0.16(4)	0.25(5))	6.88	
3967.7(1)	2815.2 0.49(2) /	0.44(2))	6.61	
3998.7(2)	2706.2 0.20(2), 2586.6 0.15(3)	0.31(4))	6.72	
4051.9(1)	2759.5 0.79(3), 2639.7 0.13(2), (1243.5(0.10(4))	0.91(6)	6.17	(1/2,3/2)
4073.7(1)	(2921.4 0.13(3)), 2661.4 0.14(2), 2374.1 0.39(4), 2225.8 0.09(2)	0.67(6)	6.26	
(4117.6(3))	(2489.6 0.11(5)), (2418.2 0.11(3))	0.20(5))	6.70	
4132.3(2)	(2979.5 0.13(2), 2840.1 0.60(6), 2719.9 0.11(2), (2432.6 0.21(2)	0.94(9)	6.08 6.00	(1/2,3/2)
4144.4(1)	2991.8 0.41(3), 2852.0 0.55(3), 2732.3 0.35(2), 2444.4 (0.15(5)), 2197.1 0.21(2)	1.50(7)	5.78	$(1/2^{-})$
4176.6(1)	3024.1 0.36(2), 2764.4 0.26(3)	0.56(4))	6.14	(1/2,3/2)
4201.2(1)	3048.6 0.25(1), 2908.8 0.29(2), 2789.1 0.54(3), 2354.2 0.12(3), (1968.5 0.05(4))	1.11(6)	5.83	(1/2)
4249.7(2)	(2957.1 0.14(3)), 2837.8 0.26(4), (2489.5 0.10(5))	0.36(6))	6.15	(1/2,3/2)
4280.4(1)	3128.3 0.21(2), 2580.8 0.20(3)	0.37(4)	6.04	(1/2,3/2)
4299.7(2)	3147.2 0.13(2), 3007.2 0.38(3)	0.46(4))	5.89	(1/2)
4369.8(5)	(3217.5 0.08(2)), 2610.0 0.06(2)	0.13(3))	6.18	(1/2,3/2)
(4431.4(3))	(3279.3 0.14(2)), (3139.0 0.06(1)), (3018.8 0.11(2))	0.27(3))	5.55	$(1/2^{+})$

a) The transitions multipolarites are from Table 1.
In brackets are transitions placed in the level scheme
of ^{147}Gd on the basis of energy relations only.

b) The levels I^{π} are taken from ref.[17,19,20].

transitions with energies up to 2 MeV are established. A new ^{147g}Tb decay scheme including 44 excited states of ^{147}Gd is proposed. Probabilities of β-transitions (logft) to the ^{147}Gd levels are determined. Conclusions on spin and parity of the level are drawn.

The results obtained are discussed in the framework of the nuclear shell model:

1. The levels: 0 keV - $2f_{7/2}$, 1152 keV - $3p_{3/2}$, 1387 keV -$1h_{9/2}$, 1847 keV - $3p_{1/2}$ and 1948 keV - $2f_{5/2}$ are considered as one-particle neutron states of the $82 < N < 126$ shell. The 1948 keV - $2f_{5/2}$ state has been observed for the first time.

2. An earlier unknown $I^{\pi}=5/2^{+}$, 1628 keV state of the $(\nu f_{7/2}x3^{-})$ multiplet has been found and thus all levels of this multiplet in the ^{147}Gd nucleus have been observed experimentally.

3. The 2233 keV and 2329 keV levels can be identified as $I^{\pi}=5/2^{-}$ and $3/2^{-}$ members of the $(\nu f_{7/2}x2^{+})$ multiplet.

4. A great number of levels with logft=5.6÷ 6.4 and I=1/2 or 3/2 observed in the 3.7÷ 4.4 MeV energy range should be interpreted as three-qusiparticle ones with a noticeable admixture of the $(\pi\ s_{1/2}, \pi\ h_{11/2}, \nu\ h_{9/2})$ component allowing the ^{147}Tb nucleus to realize a Gamow-Teller beta-transition of the spin-flip type.

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References

1. P.Kleinheinz, S.Lunardi, M.Ogawa, M.R.Maier, Z.Phys.**A284** (1978) 315.

2. P.Kleinheinz, *et al.* Z.Phys. **A290** (1979) 777.

3. M.Ogawa, *et al.* - Phys.Rev.Lett **41** (1978) 289.

4. S.A.Artamonov, V.I.Isakov, C.G.Ogloblin, V.R.Shaginyan Journal of Nucl.Phys.(Sov) **46** No 6 (1987) 1651.

5. Y.Y.Chu, E.M.Franz, G.Friedlander - Phys.Rev.Lett. **A21** (1969) 23.

6. Y.Y.Chu,E.M.Franz, G.Friedlander Phys.Rev.**187** (1969) 1529

7. Y.Nagai,*et al.* Phys.Rev.Lett. **47** (1981) 1259.

8. C.F.Liang, *et al.* Phys.Lett. **B191** (1987) 245.

9. V.P.Afanasev, *et al.* Izv. AN USSR, ser.fiz.**35** (1971) 659.

10. E.Newman, K.S.Toth, D.C.Hensley, W.D.Shmidt-Ott, Phys.Rev.**C9** (1974), 674.

11. E.Newman, K.S.Toth, D.C.Hensley, W.D.Shmidt-Ott, Phys.Rev. **C12** (1975) 346.

12. J.Kownacki, H.Ryde, V.O.Sergeev, Z.SujkowsKi, Phys.Scr. **5** (1972) 66.

13. Z.Haratym, *et al.* Nucl.Phys. **A276** (1977) 209.

14. R.Broda, *et al.* Z.Phys. **A305** (1982) 281.

15. O.Bakander,*et al.* Nucl.Phys. **A389** (1982) 93.

16. B.Haas, *et al.* Nucl.Phys. **A362** (1981) 254.

17. T.Komppa, *et al.* Z.Phys.**A314** (1983) 33.

18. H.Piiparinen, *et al.* Annual Report (1984), KFA Julich, ISSN **0170-8937** (1985) 110.

19. J.Styczen, P.Kleinheinz, M.Piiparinen, J.Blomqvist, Proc.4th Int. Conf. on Nuclei far from Stability, Helsinger (1981), CERN **81-09** 548.

20. W.A.Kaminski, J.Wawryszczuk, Proc.of the 30th Conf. on Nuclear Spectroscopy and Nucl. Structure, Leningrad, (1980) 161.

21. H.Kader, *et al.* Phys.Lett. **B227** (1989) 325.

22. C.Wylov, *et al.* Proc. 22th Conf. on Nuclear Spektroskopy and Nucl. Structure, Kiev, (1972) 107.

23. R.Manegazzo, *et al.* , Ann.Rep. KFA, Julich, (1990) 20.

24. G.V.Veselov, *et al.* Izv.AN UdSSR **47** (1983) 834.

25. W.Habenicht, *et al.* Proceedings AMCO-7, Darmstadt, (1984) 244.

26. U.L.Schreve, *et al.* Z.Phys. **A320** (1985) 595.

27. G.D.Alkhazov, *et al.* LINP, Leningrad, **1620** (1990).

28. H.Keller, *et al.* Z.Phys. **A340** (1991) 363.

29. J.Wawryszczuk, *et al.* JINR, Dubna, **R6-93-275** (1993).

30. J.Wawryszczuk, *et al.* Abstracts of the Reports of the Int.Conf. Nuclear Spectroscopy and Nuclear Structure, St.Petersburg, (1995) 67.

31. V.G.Kalinnikov, *et al.* Nucl.Inst. and Methods **B70** (1992) 62.

32. V.Gadzhokov; Prib. i Tekh.Eksp.(Sov) **5** (1970) 82.

33. Zh.Sereeter, *et al.* JINR, Dubna, **P13-94-267** (1994).

34. E.der Mateosian, L.K.Peker, NDS,**66** (1992) 705

35. V.I.Fominykh, *et al.* Prib. i Tekh. Eksp.(Sov) **5** (1995), 19.

36. G.V.Veselov, *et al.* Izv. RAN ser.fiz. **59** No 1 (1995) 39.

37. Y.V.Naumov, A.A.Bykov, I.N.Izosimov, Particles and Nuclei, Dubna **14** (1983) 421.

38. I.N.Izosimov, *et al.* Heavy Ion Physics, Scintific Report FLNR, Dubna, **1991-92**, (1993) 211.

39. C.Ekstrom, S.Ingelman, M.Olsmats, B.Wannberg, Phys.Scripta **6** (1972) 181.

40. M.Piiparinen, *et al.* Z.Phys. **A337** (1992) 387.

41. O.Hausser, *et al.* Nucl.Phys. **A379** (1982) 287.

42. P.Kleinheinz, *et al.* Phys.Rev.Lett. **48** (1982) 1457.

43. E.Dafni, *et al.* Phys.Lett. **B199** (1987) 26.

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