assignment near 50 keV (assuming a neutron width too small for detection of the resonance[9]) for the activation observed is indicated parenthetically. It gives a steeper temperature dependence, as expected.

The neutron capture areas found at the 70- and 77-keV resonances (Table I) are substantially smaller than the combined area reported earlier.[3] The earlier measurement was slightly sensitive to scattered neutrons as indicated in the reference. Probably that result should have been considered only an upper limit on the capture.

Using the isotopic composition of lead at the time solid bodies formed in the solar system,[14] we can calculate a close upper limit on the change in the $N_s\sigma$ product from ^{204}Pb to ^{208}Pb for the s-process[2] history of the solar system. ^{204}Pb is shielded from r-process contributions by stable ^{204}Hg, while the "primordial" ^{208}Pb "is due overwhelmingly to the s process."[1]

$$\frac{(^{204}\mathrm{Pb})N_s\sigma}{(^{208}\mathrm{Pb})N\sigma}=\frac{0.020\times(\mathrm{Pb})\times 43\ \mathrm{mb}}{0.585\times(\mathrm{Pb})\times 0.33\ \mathrm{mb}}=4.5.$$

(The value 43 mb is from Ref. 3.) This is well above the equilibrium value (1.0) and indicates at most a minor equilibrium component in the solar s-process material near Pb. As emphasized by Clayton and Rassbach[15] for rapidly falling neutron-exposure distributions, "in the limit of very small values of σ_{208} the solution becomes independent of the value of σ_{208}." Thus, unfortunately, the present Maxwellian averaged results (Table III) appear to lie in the "quite comfortable" range of astrophysical expectation.[16] This means that we can provide little constraint on the relevant nucleosynthesis parameters of the r and s processes even with significantly revised current abundance data, but at least we are comforted that the earlier discussions about lead[1] and the puzzles of galactic chronology are consistent with observation.

ACKNOWLEDGMENTS

We were grateful for the contribution of J. Emery who performed the β counting and foil calibration. Also, John Vitkevich was of great assistance in data taking and analysis.

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High-Spin Three-Particle States in ^{207}Bi

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High-spin three-particle levels populated in the decay of a 182± 6-μsec isomeric state in ^{207}Bi have been studied using the pulsed external beam of the Stockholm 225-cm cyclotron. The isomeric state was produced in the ^{205}Tl(28-MeV α, $2n$)^{207}Bi reaction. The intensities and energies of the 13 delayed γ transitions observed fit consistently into a level scheme of six excited levels having energies (keV) and spins: 2101.5 (21/2), 1645.4 (15/2), 1357.9 (15/2), 1240.5 (13/2), 931.8 (13/2), and 669.5 (11/2$^-$). Shell-model calculations have been performed showing that the observed levels can be interpreted as resulting from the coupling of the two-neutron-hole states in ^{206}Pb with the odd proton. From the known level structure of ^{206}Pb and the investigation of the n-p interaction in ^{208}Bi, the theoretically expected level structure of ^{207}Bi has been calculated. The average energy difference between theoretically and experimentally determined levels is as low as 18 keV, and the agreement of experimental and theoretical transition probabilities is also satisfactory. The spin assignments are confirmed, and all levels except the 21/2 are found to have odd parity.

I. INTRODUCTION

For some years, considerable interest has been focused on investigations of two-quasi- ($2q$) and three-quasi-particle ($3q$) levels in several regions of the nuclear chart. It is obvious that attention should be drawn to related $2q$ and $3q$ states which may be denoted as $(N, Z)_{2q}$ and $(N, Z\pm1)_{3q}$ or $(N\pm1, Z)_{3q}$, respectively.

Of considerable interest are two-particle states for which both N and Z are close to magic numbers, and especially attractive are related two- and three-particle states which might be relatively easily accessible for theoretical calculations; some such states are $(N\pm2, Z)$ and $(N\pm2, Z\pm1)$ or $(N, Z\pm2)$ and $(N\pm1, Z\pm2)$, where both N and Z are magic numbers.

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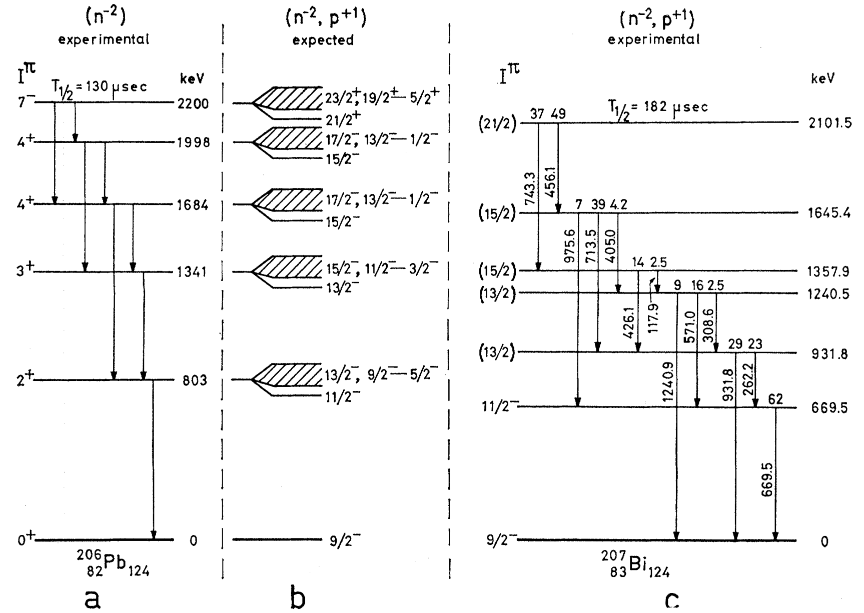

FIG. 1. (a) Experimental level scheme for the decay of the 7$^-$ isomeric state in ^{206}Pb. (b) Expected bands of levels obtained by coupling an $h_{9/2}$ proton to the ^{206}Pb levels. (c) High-spin levels of ^{207}Bi as experimentally found in the decay of an 182±6μ-sec isomer.

A systematic study of related two- and three-particle states of this type might yield valuable information about the *n-p* interaction in nuclei. It is known[1] that the effective interaction is different in nuclei compared with the interaction between free nucleons, and that tensor forces have to be included[2] in some cases of *n-p* interaction in nuclei. Furthermore, in favorable cases it may be possible to study finer details of the shell model treatment of nuclei. For instance, there is a hypothetical possibility of studying three-particle forces in nuclei.

In the lead region, it is likely that many of the states should have spins of the order of 10 because of the possible coupling between the single-neutron-hole state $i_{13/2}$ and the single-proton state $h_{9/2}$. Furthermore, many transitions are expected to correspond to half-lives in the region 10^{-8}–10^{-1} sec. The high angular momentum introduced into the compound nucleus in (particle, *xn*) reactions even at moderate particle energies and the possibilities to pulse accelerator beams make "in-beam-work" the best choice for studying the decay of these high-spin states. A program for investigating the part of the lead region which is accessible to the α beam of the Stockholm 225-cm cyclotron was started in 1967.

In ^{206}Pb there is a well-known series of two-particle neutron-hole states [cf. Fig. 1(a)]. The $(p_{1/2}, i_{13/2})7^-$ state at 2.2 MeV has a half-life of 130 μsec. In ^{207}Bi the additional $h_{9/2}$ proton should couple to the neutron-hole states in such a way that for each state in ^{206}Pb there should be a corresponding band of levels in ^{207}Bi having spins according to the vector coupling of the $h_{9/2}$ proton and the two-neutron-hole states in ^{206}Pb. Using the semiempirical rules established by Peker,[3,4] it can be assumed that the lowest level in each band should be the one with maximum possible spin minus one unit. It is known from related $2q$ and $3q$ states that the *n-p* interaction causes a splitting of the levels within the bands, which is relatively small. Usually there seems to be an energy difference between the $2q$ states and the corresponding lowest $3q$ state which is only of the order of 0.1 MeV (Ref. 4) [indicated in Fig. 1(b)].

A measurement has been reported by Conlon[5] who in the ^{208}Pb$(p, 2n)^{207}$Bi reaction found several delayed γ rays corresponding to a half-life of 174 μsec. Because of the value of this half-life it seemed plausible to assume that Conlon had produced the three-particle state in ^{207}Bi which corresponds to the known 130-μsec 7$^-$ state in ^{206}Pb. However, the information obtained by Conlon did not allow spin assignments. Furthermore, his tentative level scheme suggested a position of the 174-μsec state at 1.55 MeV above the ground state, which seemed too low to us. We therefore decided to study carefully this interesting case of isomerism. A high-spin isomer in ^{207}Bi cannot be expected to be observed in the radioactive decay of ^{207}Po. The spin of the ^{207}Po ground state[6] is $\frac{5}{2}$, and therefore only levels with spin values lower than 11/2 are observed in ^{207}Bi.[7,8] The use of an $(\alpha, 2n)$ reaction at about 28 MeV was considered advantageous because

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[3] L. K. Peker, Soviet J. Nucl. Phys. **4**, 20 (1967); J. Nucl. Phys. (USSR) **4**, 27 (1966).

[4] L. K. Peker (private communication).

[5] T. W. Conlon, Nucl. Phys. **A100**, 545 (1967).

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[7] E. Arbman, J. Burde, and T. R. Gerholm, Arkiv Fysik **13**, 501 (1958).

[8] G. Astner (private communication).

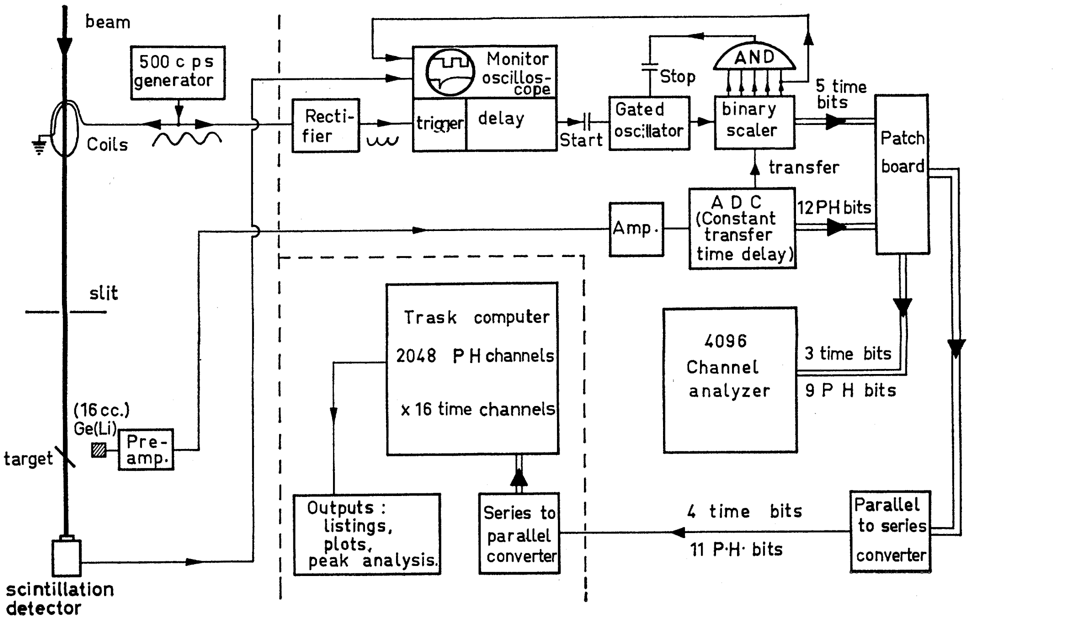

FIG. 2. Block diagram showing the experimental set-up with the TRASK computer on line. The output from a 500-cps generator is used to magnetically sweep the cyclotron beam over a slit, producing 1000 beam pulses/sec. In order to obtain a time reference signal, an oscilloscope is triggered 1000 times/sec by a rectified output from the 500-cps generator. A delayed trigger output from the oscilloscope starts a gated oscillator. Together with a scaler this oscillator serves as a binary-coded timer from which the information is transferred each time a pulse from the Ge(Li) detector has been analyzed in the analog-to-digital converter (ADC). The frequency of the oscillator is chosen to give 32 pulses in a time interval somewhat shorter than 1 msec. After 32 pulses the oscillator is stopped via the AND gate. The beam pulses and the timer pulses are monitored by the oscilloscope, and proper timing between the start pulses of the timer and the ADC transfer signals is obtained by adjusting the delay of the oscilloscope trigger output.

it should favor the population of the high spin 21/2 expected for the isomeric state in ^{207}Bi, and because it would give a confirmation of the mass assignment of the 174 μsec isomer reported by Conlon. Preliminary results of the present experiment were included in a recent survey lecture on $2q$ and $3q$ isomeric states.[9]

II. EXPERIMENTAL PROCEDURE

The experimental procedure used is schematically shown in the block diagram presented in Fig. 2. As indicated, the α-particle beam was chopped by sweeping it over a slit by means of an ac magnetic field. The pulse length was about 50 μsec and the time between the pulses 1 msec. In the preliminary runs the pulses from the 16-cc Ge(Li) detector were analyzed using a 4096 channel analyzer. The analyzer was used in an 8×512 two-dimensional configuration (8 time channels by 512 energy channels). The results obtained were used for planning the later measurements in which TRASK, the computer of this institute, was connected to the experiment via a special interface.[10] The whole system worked as a two-dimensional 32 768-channel analyzer (16 time channels by 2048 energy channels). The first 15 time channels, each 47 μsec wide, were used for registering delayed events. The last time channel (∼300 μsec wide) was adjusted to coincide with the beam pulse and thus to register both prompt and delayed events. Time calibration was performed using a Tektronix precision time marker. The energies of the prompt and delayed γ rays were accurately measured in a separate experiment by registering simultaneously the γ rays in ^{207}Bi and γ rays from calibration sources. For these experiments a smaller Ge(Li) detector having better energy resolution was used (2.5 cc, 1.5 keV at 122-keV γ energy) and, for intensity reasons, the beam was not pulsed. In all experiments the target was about 10 mg/cm^2 of enriched ^{205}Tl$_2$O$_3$ sandwiched between thin Formvar foils (∼100 μg/cm^2).

III. EXPERIMENTAL RESULTS

Figure 3 shows a delayed γ-ray spectrum recorded in the time interval ∼(150–385) μsec after the beam pulses. Table I contains the energies and intensities of the γ rays which because of their half-lives have been assigned to the isomeric decay. Within the experimental errors the rate of decay observed for all these γ rays coincide and lead to a value of 182±6 μsec for the half-life of the isomeric state.

On the basis of the information obtained from the delayed spectra we have arrived at the level scheme

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[9] K. F. Alexander, in *Proceedings of the Dubra Symposium on Nuclear Structure* (International Atomic Energy Agency, Vienna, 1968).

[10] L. Harms-Ringdahl and J. Sztarkier (to be published).

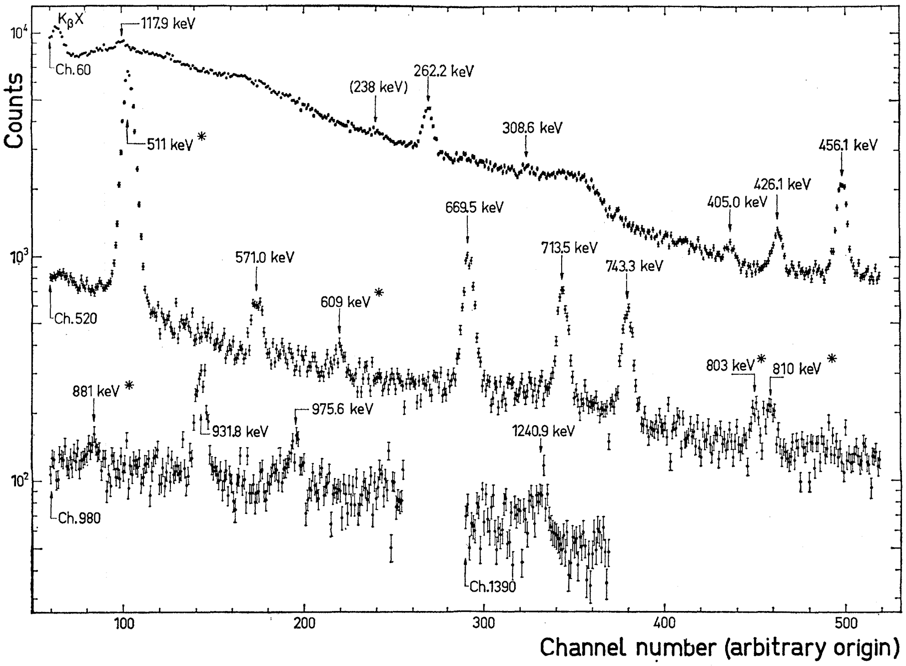

FIG. 3. Spectrum of delayed γ rays emitted in the $^{205}\mathrm{Tl}(\alpha, 2n)^{207}\mathrm{Bi}$ reaction. Shown are events observed during a 235-μsec-long time interval starting about 150 μsec after the beam pulses. The γ rays marked with an asterisk (*) have a much longer decay period than the others, and therefore do not belong to the investigated isomeric decay.

presented in Fig. 1(c). The justification for this level scheme is that within the experimental errors it fulfils intensity and energy requirements and that it covers all delayed γ rays observed. The given combination of spins is the most consistent and plausible one in the light of the following arguments. However, with the presently available experimental information other spin assignments cannot be completely ruled out.

Ground state $9/2^-$: In analogy with measured ground-state spins for other odd Bi isotopes.[11]

669.5 *keV* $11/2^-$: Assignment from radioactive decay experiments.[8,9]

931.8 *keV* (13/2): Level decays to the 669.5-keV level as well as to the ground state, but is not populated in the radioactive decay from the $5/2^-$ ground state in ^{207}Po.

1240.5 *keV* (13/2): Level decays to the $9/2^-$, $11/2^-$, and to the (13/2) states, but is not seen in the ^{207}Po decay.

1357.9 *keV* (15/2): Level decays only to the two lower (13/2) levels.

1645.4 *keV* (15/2): Level decays only to the two (13/2) levels and to the $11/2^-$ level.

2101.5 *keV* (21/2): Level communicates only with the lower two (15/2) levels and the isomeric half-life is only in accordance with multipolarity $E3$.

The observed γ intensity branching ratios serve as a further support for the spin assignments. Assuming s.p. transitions rates these ratios are all in reasonable agreement with the assigned spin values. However, one discrepancy is observed and should be pointed out. If the two transitions depopulating the isomeric level are assigned $E3$, the relative intensity of the 743.3-keV γ transition is found to be surprisingly low as compared with the 456.1-keV γ intensity. From s.p. estimates the 743.3-keV γ transition is supposed to be about 30 times stronger than 456.1-keV one, but is experimentally found to be weaker. This problem will be discussed and clarified in Sec. IV.

Though the consistency of the level scheme is very

TABLE I. Energies and intensities of γ transitions observed in the delayed spectra.

Energy (keV)	Relative intensity
117.9±0.4	2.5±0.4
262.2±0.1	23±3
308.6±0.2	2.5±0.7
405.0±0.2	4.2±0.8
426.1±0.2	14±2
456.1±0.1	49±5
571.0±0.1	16±2
669.5±0.1	62±6
713.5±0.2	39±4
743.3±0.15	37±4
931.8±0.2	29±3
975.6±0.4	7±2
1240.9±0.7	9±2

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[11] I. Lindgren, in *Alpha-, Beta-, and Gamma-Ray Spectroscopy*, edited by K. Siegbahn (North-Holland Publishing Company, Amsterdam, 1965).

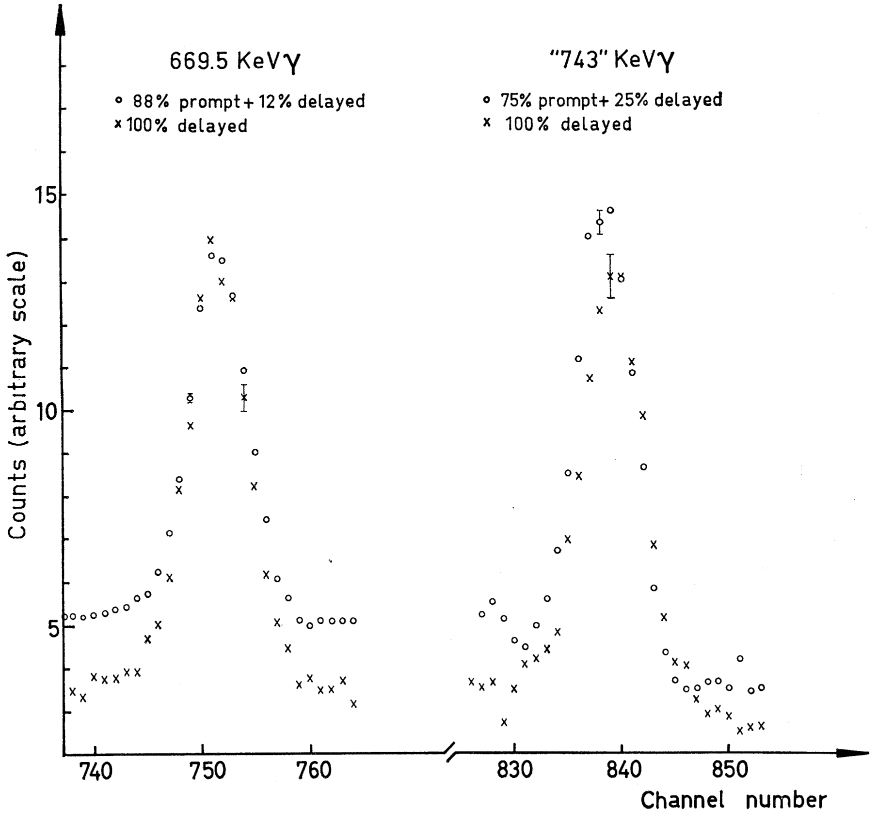

FIG. 4. 743-keV γ ray as observed in "prompt" and delayed spectra. The small shift in channel number observed corresponds to an energy difference of 0.8 keV between the two 743-keV γ transitions. For comparison the simultaneously recorded lines of 669.5 keV are shown.

satisfying a few comments should be made. The intensities given in Table I and in Fig. 1(c) are recorded γ-ray intensities and are normalized to give an intensity of 100 for the γ-ray transitions leading to the ground state. For the stronger lines the estimated errors are almost solely due to uncertainties in the efficiency calibration of the detector, whereas for the weakest lines also statistical errors and those associated with the estimation of background are of importance. For some of the levels the intensity balance should be commented. Thus there seems to be a discrepancy for the 669.5- and 1357.9-keV levels. However, inclusion of

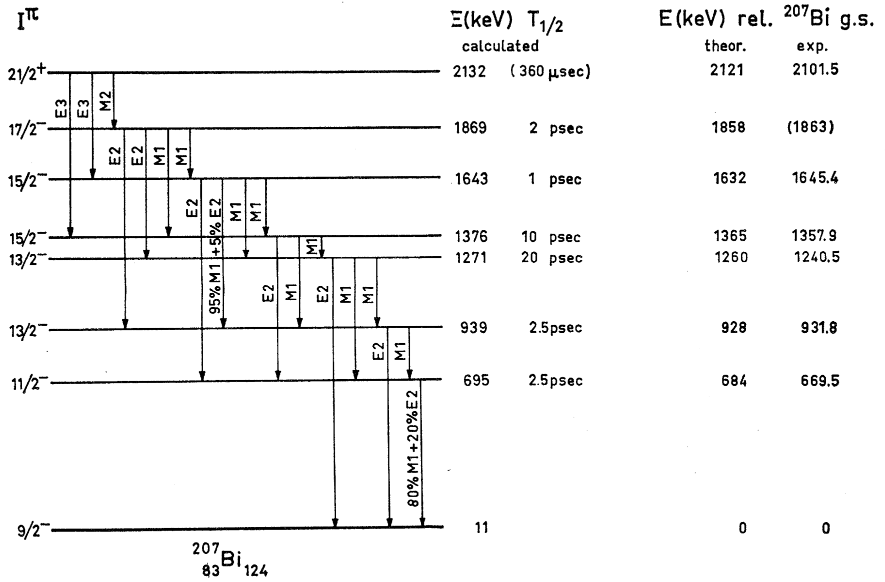

FIG. 5. Theoretically calculated high-spin levels in ^{207}Bi (see also Table IV). To the right the level energies referred to the ground-state energy are compared with the experimentally found values. Relative transition rates are calculated for the indicated transitions (for a comparison with the experimental information see Table V).

the expected internal conversion intensities for the 117.9- and 262.2-keV transitions takes care of this discrepancy. These transitions are both likely to be $M1$ transitions having conversion coefficients of $\beta_1(K117.9)=5.20$ and $\beta_1(K262.2)=0.552$. None of the other transitions should have conversion intensities of any importance for the comparisons of feeding and decay of individual levels. The introduction of the conversion intensity of the 262.2-keV transition, however, makes the intensity agreement for the 931.8-keV level somewhat marginal, showing a too strong depopulation of this levels. This will be further discussed below.

The only remaining intensity discrepancy is connected with the isomeric 2101.5-keV level. The sum of the intensities of the two depopulating transitions amounts only to 86±7 units, and transition intensity of about 14 units is thus missing. Also this discrepancy can be explained in a plausible way. Here, however, the experimental information has to be supplemented by the theoretical calculations according to which an 1869-KeV $17/2^-$ state should be weakly populated in the decay of the isomeric state. In fact, using this guidance, a weak transition of 238±1 keV with a γ intensity of 2.5±1 units was found in the delayed spectra. Also, its half-life is found to be of the right order. If this is the theoretically expected transition it should be an $M2$ transition and therefore mainly proceed by internal conversion electrons $[\beta_2(K238)=2.80]$. The decay of the 1863-keV state fed by such a transition should go mainly by $M1$ radiation to the lowest $15/2^-$ level or by $E2$ radiation to the lowest $13/2^-$ level or a combination of these two possibilities. The $M1$ alternative implies a transition energy of 505 keV, which cannot be observed because of the strong annihilation radiation. The $E2$ alternative leads to a transition energy of 931 keV, which suggests that the observed 931.8 keV transition is a doublet. It is worth noticing that such a doublet structure would take care of the slight intensity disagreement for the 931.8-keV

TABLE II. Energy levels in ^{206}Pb.

J	Energy (keV)
0^+	0
2^+	803
0^+	1165
3^+	1341
2^+	1464
4^+	1684
4^+	1998
7^-	2200
6^-	2385

TABLE III. Interaction energy matrix elements in neutron-hole–proton configurations.

Configurations		J	Matrix elements (keV)
$p_{1/2}h_{9/2}$	$f_{5/2}h_{9/2}$	4	+109
		5	+121
$p_{1/2}h_{9/2}$	$p_{3/2}h_{9/2}$	4	+120
		5	−81
$f_{5/2}h_{9/2}$	$p_{3/2}h_{9/2}$	3	−144
		4	+75
		5	−64
		6	+74
$p_{1/2}h_{9/2}$	$f_{7/2}h_{9/2}$	4	+121
		5	−66
$f_{5/2}h_{9/2}$	$f_{7/2}h_{9/2}$	2	+250
		3	−79
		4	+97
		5	−65
		6	+68
		7	−69
$p_{3/2}h_{9/2}$	$f_{7/2}h_{9/2}$	3	+146
		4	+111
		5	+54
		6	+153
$p_{1/2}h_{9/2}$	$p_{1/2}h_{9/2}$	4	+176
		5	+107
$f_{5/2}h_{9/2}$	$f_{5/2}h_{9/2}$	2	+473
		3	+198
		4	+117
		5	+144
		6	+31
		7	+166
$p_{3/2}h_{9/2}$	$p_{3/2}h_{9/2}$	3	+222
		4	+121
		5	+46
		6	+297
$i_{13/2}h_{9/2}$	$i_{13/2}h_{9/2}$	8	+110
		9	+239
		10	+20
		11	+881

TABLE IV. Calculated energies[a] and wave-function amplitudes for states in ^{207}Bi.

		Wave-function amplitudes								
j^π	Energy (keV)	$0_1^+, h_{9/2}$	$2_1^+, h_{9/2}$	$0_2^+, h_{9/2}$	$3_1^+, h_{9/2}$	$2_2^+, h_{9/2}$	$4_1^+, h_{9/2}$	$4_2^+, h_{9/2}$	$7_1^-, h_{9/2}$	$6_1^-, h_{9/2}$
$9/2^-$	11	+0.961	−0.274	+0.011	−0.005	+0.015	−0.038	+0.008		
$11/2^-$	695		+0.998		−0.009	−0.017	−0.003	−0.054		
$13/2^-$	939		+0.958		−0.067	+0.071	−0.267	+0.038		
$13/2^-$	1271		+0.070		+0.953	−0.281	−0.071	−0.059		
$15/2^-$	1376				+0.980		−0.121	−0.157		
$15/2^-$	1643				+0.110		+0.991	−0.074		
$17/2^-$	1869						+0.896	+0.443		
$21/2^+$	2132								+0.988	−0.155

[a] The energies are given relative to the experimental ground-state energy of ^{207}Bi, obtained from the binding energies of ^{207}Bi, ^{206}Pb, ^{209}Bi, and ^{208}Pb.

level discussed above. However, since the experimental evidences are not conclusive, a possible 1863-keV level has not been included in Fig. 1(c). To definitely establish the existence of an 1863-keV level, experiments including conversion electron studies and coincidence studies should be performed.

The 743.3-keV transition caused a difficulty in the interpretation of our spectra. In the decay of ^{207}Po a 742.6-keV transition is observed,[7,8] which is emitted from a $7/2^-$ state at 743 keV in ^{207}Bi. However, a study of the energy-sum-relations of the delayed γ rays strongly suggested that the observed 743.3-keV γ ray could not correspond to a ground state transition. This was confirmed by a careful comparison of the delayed and prompt spectra (see Fig. 4) which demonstrated an energy shift of 0.8 keV for the 743-keV γ ray depending on whether it was observed in a prompt or a dealyed spectrum. This shift was not present for the 669.5-keV transition or any of the other gamma rays observed. Thus there exist two transitions of almost the same energy in ^{207}Bi, of which only one is observed in the isomeric decay. No indications are found for a population of the $7/2^-$ 742.6-keV state from the isomeric decay. The final conclusion therefore is that the suggested level scheme covers our experimental information very well.

IV. THEORETICAL DISCUSSION

A shell-model calculation has been carried out for the lowest high-spin levels in ^{207}Bi.[12] The calculated energies and half-lives are shown in Fig. 5, and a comparison between observed and calculated γ branching ratios is given in Table V.

The interactions between the three particles (two neutron holes and one proton) added to the ^{208}Pb core are calculated in two steps. First, the interaction between the two neutron holes is taken into account by using the known levels[13] in ^{206}Pb and the single-proton levels in ^{209}Bi, with their observed energies, to form a set of basis states for ^{207}Bi. In this way we obtain multiplets of degenerate states with spins j determined by the coupling of the spin of the neutron holes J_n and the spin of the proton J_p, $j=\bar{J}_n+\bar{J}_p$. It turned out to be adequate to use only the $h_{9/2}$ proton state in this calculation of high-spin levels. The next proton state $f_{7/2}$ has an excitation energy of 0.90 MeV and the states built on that orbital come at too high energies to be populated in the isomeric decay. They are also weakly coupled to the states which are built on the $h_{9/2}$ orbital. The neutron hole states which have been used are given in Table II.

In the second step the interaction between the neutron holes and the proton is calculated and the energy matrices diagonalized. For this purpose we need to know the wave functions of the ^{206}Pb states and the matrix elements of the interaction energy between a neutron hole and a proton. The ^{206}Pb wave functions were taken from the recent calculations of True.[14] To obtain the relevant $\bar{n}p$ matrix elements (cf. Table III) we have combined the results of calculations on ^{208}Bi by Kim and Rasmussen[15] and the recent experimental results on the levels of this nucleus by Alford *et al.*[16] The nondiagonal matrix elements were obtained from the calculations in Ref. 15 and the diagonal matrix elements from Ref. 16, after subtraction of calculated energy shifts due to configuration mixing.

The transition rates were calculated with the following input values. For the $E3$ transitions we used $B(E3)$

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[12] J. Blomqvist's detailed report on these calculations including low-spin levels is to be published.

[13] C. M. Lederer, J. M. Hollander, and I. Perlman, *Tables of Isotopes* (John Wiley & Sons, Inc., New York, 1967), 6th ed.

[14] W. W. True, Phys. Rev. **168**, 1388 (1968).

[15] Y. E. Kim and J. O. Rasmussen, Phys. Rev. **135**, B44 (1964).

[16] W. P. Alford, J. P. Schiffer, and J. J. Schwartz, Phys. Rev. Letters **21**, 156 (1968).

TABLE V. Relative γ transition probabilities.

Experimental level energy (keV)	Transitions considered (keV)	Relative γ intensity Experimental	Theoretical
2101.5	743:456:(238)	0.75:1:(0.05)	0.01:1:0.1
(1863)	(931):(623):(505):(218)	···	1:0.01:0.8:0.4
1645.4	976:714:405:(287)	0.2:1:0.11:(<0.05)	0.35:1:0.2:0.005
1357.9	(688):426:118	(<0.1):1:0.18	0.01:1:0.10
1240.5	1241:571:309	0.6:1:0.16	0.2:1:0.1
931.8	932:262	1:0.82	1:0.7

values obtained from ^{206}Pb,

$$B(E3,\ 7_1^- \to 4_1^+) = 880\ e^2\ \mathrm{fm}^6,$$

$$B(E3,\ 7_1^- \to 4_2^+) = 660\ e^2\ \mathrm{fm}^6.$$

The $E2$ transition rates were calculated with effective charges

$$e_{\mathrm{eff}}\ (\mathrm{neutron}) = 0.8\ e,$$

$$e_{\mathrm{eff}}\ (\mathrm{proton}) = 1.4\ e,$$

and all radial matrix elements $\langle r^2 \rangle = 35\ \mathrm{fm}^2$.

For the $M1$ transitions we used $\mu(\bar{p}_{1/2}) = +0.59\ \mu_N$, $\mu(\bar{f}_{5/2}) = +0.65\ \mu_N$, and $\mu(h_{9/2}) = +4\,08\ \mu_N$ and $g_{s,\mathrm{eff}} = 0.7 g_{s,\mathrm{free}}$ for other matrix elements.

As shown in Fig. 5 there is a remarkable agreement between the experimental and theoretical energies. The average deviation for the seven establish levels is 18 keV. The calculation has given a $17/2^-$ level at 1869 keV which should be fed weakly from the $21/2+$ level by an $M2$ transition. Besides this level no other levels have been found in the calculation which should be populated with measurable intensity in the isomeric decay scheme.

As can be seen from Table IV, the lowest three-particle states are shifted by about 100 keV from the parent two-particle states as expected.[4] The splittings within some multiplets are, however, of up to 500 keV (considering also low spin states[12] not included in Table IV). Furthermore, appreciable mixing takes place between states of different multiplets separated by several hundred keV.

The theoretical reduced transition probability for the low-energy $E3$ transition is

$$B[E3,\ (21/2^+)_1 \to (15/2^-)_2] = 740\ e^2\ \mathrm{fm}^6,$$

which agrees well with the observed value of 860 e^2 fm^6. The high-energy $E3$ transition is strongly retarded both theoretically and experimentally. The calculated absolute rate is too small but this should not be taken too seriously, since it is very sensitive to the small components in the wave functions.

The relative transition rates in Table V show fair agreement with experiments. In particular we wish to point out that the admixture of the $(4_1^+, h_{9/2})_{13/2}$ structure into the lowest $13/2^-$ state is essential for bringing up the rate of the 714-keV $M1$ transition.

In our opinion the agreement between the experimental and theoretical decay schemes leaves little doubt about the correctness of the previously assigned spins. Further experimental information about spins and multipolarities would certainly be valuable.

The situation is very favorable for a shell-model calculation of low-lying levels in ^{207}Bi because one has access to empirical two-body matrix elements from ^{206}Pb and ^{208}Bi. It is therefore not surprising to find that a calculation like this gives rather accurate energies. The inclusion of more configurations in the calculations[12] leads to a further improvement of the agreement between the theoretical and experimental level schemes. This agreement also extends to the energies and assignment of the low spin states observed[8] in the decay of ^{207}Po. It can be concluded that ^{207}Bi seems to be a striking example of the already well established success of the shell model in the lead region.[17]

It may be possible to use this nucleus as a test case in searching for effects of an effective three-nucleon force. The present calculation indicates that the diagonal three-body interaction energy between the three nucleons added to ^{208}Pb cannot be considerable larger than 18 keV in the considered levels.

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[17] D. A. Bromley and J. Weneser, Comments Nucl. Particle Phys. 2, 151 (1968).