Gamma Transitions Feeding the 4-msec, 13/2+ Level of ^{205}Pb in the Decay of ^{205}Bi†

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The decay of 14.5-day ^{205}Bi has been reexamined, using delayed coincidence techniques, to establish which of the known γ-ray transitions feed the 4-msec, $13/2^+$ isomeric level in ^{205}Pb. The 987.8-keV transition in ^{205}Pb was used as a signature for the decay of the $13/2^+$ level. The data indicate that three transitions of energy 580.0, 1208.3, and 1552.2 keV, with respective relative intensities of 17.4, 7.6±1.1, and 6.1±0.8, are in delayed coincidence with the 987.8-keV transition. The sum of these transition intensities is in good agreement with the summed intensity of all transitions known to depopulate the isomeric level. In addition, prompt coincidence data indicate that the 550.1-keV transition feeds the 1043.7-keV level of ^{205}Pb. Evidence is presented that the 1043.7-keV level is $\frac{7}{2}^-$ instead of the previous assignment of $\frac{5}{2}^-$.

INTRODUCTION

SEVERAL investigations[1–10] have been made of the K capture decay of ^{205}Bi. This previous work has resulted in a knowledge of the main facets of the energy level scheme for ^{205}Pb. However, because of the complexity of the problem several features of the energy level diagram are still open to further investigation. Such is the case with the transitions feeding the 4 msec, $13/2^+$ isomeric level in ^{205}Pb at 1013.8 keV.[10]

Using delayed coincidence techniques, an investigation was made to determine which γ-ray transitions following the electron capture decay of ^{205}Bi populate the 1013.8-keV isomeric level in ^{205}Pb. In addition, an analysis of prompt coincidence data has yielded results which suggest a new spin assignment for the 1043.7-keV level in ^{205}Pb.

SOURCE

Several sources were used during the course of this experiment. All of them were made by irradiating radiogenetic lead with protons in a cyclotron,[9] which produces ^{205}Bi through the reaction ^{206}Pb$(p,2n)$. The sources were allowed to decay sufficiently long before use, usually two months or more, so that the 6-day ^{206}Bi activity was negligible. ^{205}Bi has a half-life of 14 days. For one of the sources, the presence of an unusually large amount of ^{207}Bi (28 years) caused its use to be discontinued while considerable ^{205}Bi activity was still present. However, this problem was not present with the other sources. The Bi activity was not chemically separated from the Pb target material. Usually a few milligrams of the irradiated Pb target were simply dissolved in acid and a few drops of this solution were placed in a test tube to form the source. In one case the radioactive material was in the form of a powder. This was placed in the bottom of a test tube to form the source.

DETECTOR

The detector used in this experiment was a standard 3 in.×3 in. NaI(Tl) integral unit scintillation crystal. It had a 2-in. deep, 0.791-in. diameter well. The intrinsic efficiency of this detector may be approximated by using the sum of the intrinsic efficiencies of a 1-in. thick, 3-in. diameter NaI(Tl) crystal and a 2-in. thick, 3-in. diameter NaI(Tl) crystal.[11] Here the source-to-detector distance would be assumed to be zero. This approximation may be improved upon by extending the calculations in Ref. 11 for the actual geometry of the detector used in this experiment. This was done using the LASL 7094 computer. It was assumed in this calculation that the source was effectively 0.25 in. above the bottom of the well. The relative detection efficiency of the crystal for γ rays of various energies was not particularly sensitive to the effective height of the source above the bottom of the well. The results of this calculation were used in this work for the efficiency of the detector.

Usually the source was surrounded by a graded absorber of Cd and Cu which attenuated the intensity of the K x ray. The attenuation of γ rays in this composite absorber, consisting of 660 mg/cm^2 of Cd which surrounded the source and which was in turn surrounded by a 406-mg/cm^2 Cu absorber, was determined experimentally. The peak to total ratios as a function of γ-ray energy for sources placed inside the well were also measured. These turned out to be quite close to

† A more complete report of this research was included in a thesis submitted in partial fulfillment of the requirements for the M.S. degree.
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[1] M. Schmorak *et al.*, Nucl. Phys. **2**, 193 (1956).
[2] A. R. Fritsch and J. M. Hollander, J. Inorg. Nucl. Chem. **6**, 165 (1958).
[3] D. E. Alburger and M. H. L. Pryce, Phys. Rev. **95**, 1482 (1954).
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[6] D. E. Alburger, Phys. Rev. **118**, 1076 (1960).
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[8] C. J. Herrlander, Arkiv Fysik. **20**, 71 (1961).
[9] S. H. Vegors, R. L. Heath, and D. G. Proctor, Nucl. Phys. **48**, 230 (1963).
[10] K. E. Bergkvist and R. Stockendal, Arkiv Fysik. **27**, 339 (1964).
[11] S. H. Vegors, L. L. Marsden, and R. L. Heath, U. S. Atomic Energy Commission Report No. IDO-16370 (1958) (unpublished).

values previously obtained for sources external to the crystal.[11]

TRANSITIONS FEEDING THE ISOMERIC LEVEL

The 987.8-keV γ ray in ^{205}Pb was used as a signature for the decay of the isomeric level. This transition was chosen since previous work[1,4–9] had shown that approximately 90% of the decays of the isomeric level proceed through this branch. In addition, this transition has a convenient energy with which to work.

The efficiency for the detection of this transition was enhanced by placing the source near the bottom of a 2-in. deep well, 0.791 in. in diameter in a 3 in.$\times$3 in. NaI(Tl) detector. In order to attenuate the intense Pb K x ray which is due to the fact that ^{205}Bi decays by K capture, the source was surrounded by a graded absorber of Cd and Cu. This arrangement effectively eliminates the γ ray, K x-ray sum peaks[7] which result from the high efficiency of the detector for K x rays. With a single channel pulse-height analyzer window which accepted $\frac{2}{3}$ of all the events in the 987.8-keV photopeak, the over-all efficiency for detecting the decay of the isomeric level was 12.3%.

A spectrum of the transitions feeding the isomeric level was obtained by modifying a TMC Model 404 pulse-height analyzer so that it would store in its memory only those events from the detector which were followed within 4 msec (after a 10 μsec delay to avoid prompt coincidences) by an output from a single channel pulse-height analyzer which was centered on the 987.8-keV photopeak. Figure 1 shows a block diagram of the electronics used to accomplish this. The ESC+ pulse is the pulse which commands the analyzer to store information in its memory. One deficiency with this arrangement was that no pulse was sent into the multichannel analyzer to reset the address registers if the analyzed pulse was not stored. This has the effect of causing some events to be rejected which would not normally have been rejected. However, since the loss of

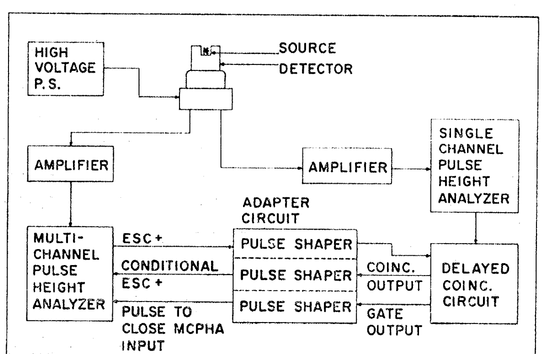

FIG. 1. Block diagram of the electronics used to determine the transitions feeding the isomeric level.

events occurred in a random fashion, the shape of the spectra obtained was not distorted. This fact was confirmed experimentally by examining spectra where the storage cycle was initiated in a manner uncorrelated in time with the activity being observed.

Figure 2 shows the results of one of the delayed coincidence measurements. The open circles are the data obtained in the manner described above. The upper solid line is a spectrum of the ^{205}Bi activity taken with the multichannel pulse-height analyzer operated in the conventional manner. This then constitutes the chance delayed coincidence background. This background spectrum is normalized to the total spectrum using the

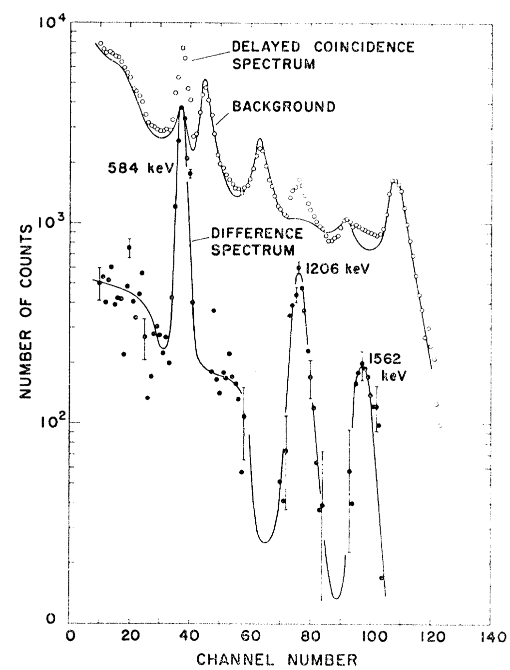

FIG. 2. A spectrum of the γ rays feeding the isomeric level. The result of subtracting the chance coincidence background, solid line, from the delayed coincidence spectrum, open circles, is the difference spectrum, black circles. A few illustrative error bars are shown. Photopeaks in the difference spectrum are quite evident at energies of 584, 1206, and 1562 keV.

1766-keV photopeak. The spectrum obtained by subtracting off the chance delayed coincidence background is shown by the solid circles. The three prominent peaks seen there are at 584$\pm$5, 1206$\pm$10, and 1562$\pm$20 keV. The energy calibration was made using the photopeaks of ^{22}Na-511, 1274, and 1785 keV (sum peak), ^{60}Co-1173 and 1332 keV, ^{137}Cs-662 keV, ^{54}Mn-835 keV, ^{40}K-1460 keV and ^{207}Bi-569, 1064, and 1633 keV (sum peak). Care was taken to keep the intensities of the calibration sources close to that of the ^{205}Bi source.

Using standard spectrum stripping techniques, the relative intensities of the 580.0-, 1208.3-, and 1552.2-keV transitions were found to be 17.4, 7.6$\pm$1.1, and 6.1$\pm$0.8, respectively. The intensity of the 580.0-keV transition has been set equal to 17.4 to make the results given here directly comparable to those in Ref. 9.

In Fig. 2 the Compton edges of the transitions are somewhat rounded off. This effect is typical of spectra taken with the source inside the well crystal. It is undoubtedly due to the fact that the low-energy scattered photons associated with the Compton edge are quite unlikely to escape from the crystal without being reabsorbed.

TRANSITIONS FOLLOWING THE DECAY OF THE ISOMERIC LEVEL

The K x rays, 580.0-, 1208.3-, and the 1552.2-keV transitions were respectively used to initiate a 4-msec long gate whose front edge was delayed 10 μsec. This gate was then fed into the TMC 400 channel pulse-height analyzer causing it to switch from the coincidence mode to the anticoincidence mode. Since no pulses were fed into the coincidence pulse input of the multichannel analyzer, only those pulses arriving during this 4 msec gate were counted.

The results of a measurement made using the 580.0-keV transition to initiate the gate is shown in Fig. 3. Similar spectra were taken using the K x rays, 1208.3- and 1552.2-keV transitions to initiate the 4-msec gate. All these spectra agreed with each other within statistics.

In Fig. 3, the upper circles are the data points. The solid line is the background, or chance coincidence spectrum. This background spectrum was normalized to the data using the 1766-keV photopeak. The result of subtracting off the background is shown as the "difference spectrum". A few illustrative error bars are also shown. Photopeaks are evident at 990, 715, and 290 keV. These are interpreted as the 987.8-, 703.4-, and 284.2-keV transitions in ^{205}Pb.

The analysis of the difference spectrum to obtain the relative intensities of the 284.2-, 703.4-, and 987.8-keV transitions is complicated by several factors. These are: (a) Sizable summing effects. Because of the efficient geometry of the detector, it is quite common for 284.2- and 703.4-keV γ rays which are in prompt coincidence to both be detected simultaneously by the NaI crystal. When this happens the event is said to be "summed out" of the 284.2- and the 703.4-keV photo peaks. If both the 284.2- and the 703.4-keV transitions interact with the detector via the photoelectric effect, the simultaneous detection of both events will appear as an event in the 987.8-keV photopeak. When this happens the event is said to be "summed into" the 987.8-keV photopeak. (b) Uncertainty in the total conversion coefficient (α_T) of the 284.2-keV transition. If this transition is pure $M1$, $\alpha_T \approx 0.50$.[12] However, the existing data do not exclude a significant $E2$ admixture, which means that α_T could be considerably less than 0.5.

[12] A. L. Sliv and L. M. Band, Leningrad Physico-Technical Institute Reports 1956, 1958 [English transl.: Reports 57ICCK1 and 58ICCL1, issued by the Physics Department, University of Illinois, Urbana, Illinois (unpublished)].

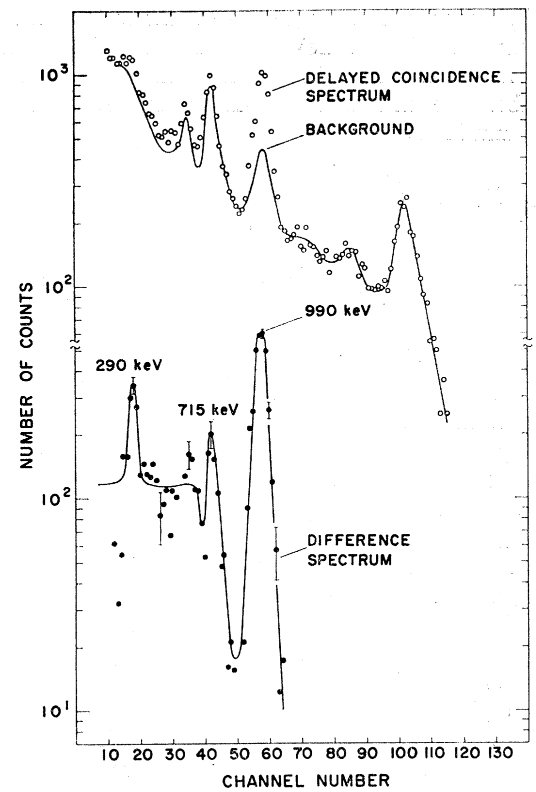

FIG. 3. A spectrum of the γ rays following the decay of the isomeric level. In this measurement the 580.0-keV transition was used to indicate the formation of the isomeric level. The result of subtracting the chance coincidence background, solid line, from the delayed coincidence spectrum, open circles, is the difference spectrum, black circles. A few illustrative error bars are shown. Photopeaks in the difference spectrum at 290 and 990 keV are quite evident. A photopeak at 715 keV is not incompatible with this data.

The number of events in the 284.2-keV photopeak corrected for summing is given by

$$N_{284} = n_{284}/[1-\epsilon_{703}(P/T')_{703}A_{703}(1/1+\alpha)_{703}], \quad (1)$$

where N_{284} is the number of events which would be in the 284-keV photopeak if there were no summing, n_{284} is the experimentally determined number of events in the 284-keV photopeak, ϵ_{703} and A_{703} are, respectively, the intrinsic efficiency of the detector and a correction for events stopped in any absorber between the source and the detector—all for the 703-keV transition. $(P/T')_{703}$ is the ratio of the number of events in the 703-keV spectrum having energies greater than 30 keV to the total number of events in the 703-keV spectrum. This factor is used instead of the normal peak-to-total ratio since any event in the spectrum of the 703-keV transition which has an energy >30 keV and which occurs at the same time as an event in the 284-keV photopeak would sum this event *out of* the 284-keV photopeak but *not necessarily into* the 987.8-

keV photopeak. Finally $(1+\alpha)_{703}$ is the total transition intensity of the 703-keV transition. For the 703-keV $E2$ transition[1,4] α is 0.01.[12] In a similar fashion the number of events in the 703-keV photopeak corrected for summing is

$$n_{703}=N_{703}\left[1-\left(\frac{\epsilon(P/T')A}{1+\alpha}\right)_{284}-\left(\frac{\alpha_K}{1+\alpha}\right)_{284}F_K(P/T)_K\epsilon_K A_K\right], \quad (2)$$

where the last term is necessary only if there is no Cd and Cu absorber between the source and the detector. This term represents events summed out of the 703-keV photopeak due to coincidences with K x rays associated with K conversion of the 284-keV transition. F_K is the fluorescent yield for the K x rays, while $(P/T)_K$, ϵ_K, and A_K are the peak-to-total ratio, detector efficiency and absorber correction for the K x rays. In those cases where no absorber is present, that is, where the K x rays are used to indicate the formation of the isomeric level, the intensity of the 703-keV transition is divided approximately evenly between photopeaks at 703 keV and at 703+72 keV. This latter photopeak is the sum peak of the 703-keV γ rays and the 72-keV K x rays, the K x rays coming from K conversion of the 284-keV transition. As a result of this, together with the fact that the 703-keV transition is only 10% as strong as the 987-keV transition, it is very difficult to obtain a meaningful value for the 703-keV γ-ray transition intensity from this spectrum. Therefore, relative intensities for the 284- and 987-keV transitions only were taken from this data. The number of events in the 987-keV photopeak is given by

$$N_{987}=n_{987}-N_{284}(1+\alpha)_{703}{}^{-1}\epsilon_{703}(P/T)_{703}A_{703}. \quad (3)$$

Once the number of events in the photopeaks has been obtained, i.e., N_i, then the transition intensities I_i, and the γ-ray intensities, G_i, are obtained from the usual relations;

$$I_i=N_i(1+\alpha)_i/[\epsilon_i(P/T)_iA_i], \quad (4)$$

and

$$G_i=I_i/(1+\alpha)_i. \quad (5)$$

The number of events in the 284- and 987-keV photopeaks from delayed coincidence spectra of events following the K x rays and the 580- and 1208-keV transitions were used to obtain the intensities of the 284- and 987-keV transitions. In the spectrum of delayed coincidence events following the 580-keV transition, events in the 703-keV photopeak were used to obtain the intensity of the 703-keV transition. From these data, the relative γ ray and transition intensities of the 284-, 703-, and 987-keV transitions were computed. These results are tabulated in Table I. The errors in the above ratio were obtained by propagating the statistical counting errors plus

TABLE I. Relative γ ray and transition intensities.[a]

0.118±0.014	G_{284}/G_{987},	0.175±0.021	I_{284}/I_{987}
0.184±0.061	G_{703}/G_{987},	0.186±0.062	I_{703}/I_{987}
0.630±0.228	G_{284}/G_{703},	0.936±0.340	I_{284}/I_{703}
0.118±0.014	G_{284}/G_{987},	0.175±0.025	I_{284}/I_{987}
0.184±0.064	G_{703}/G_{987},	0.186±0.065	I_{703}/I_{987}
0.630±0.237	G_{284}/G_{703},	0.936±0.373	I_{284}/I_{703}

[a] The results in the upper half of the table correspond to errors of ±10% for the values of α and α_K for each of the three transitions. In the lower half of the table errors of ±0.2 for α and α_K for the 284-keV transition are assumed while the errors in α and α_K for the other two transitions remained at ±10 %.

assumed errors in the values of ϵ_i, $(P/T)_i$, etc. through the calculation using standard statistical methods, that is,

$$\partial^2 f(a,b,\cdots)=(\partial f/\partial a)^2\delta^2 a+(\partial f/\partial b)^2\delta^2 b+\cdots. \quad (6)$$

The results in the upper half of the table assume that the values of α_K and α for all the transitions are accurate to within ±10%. If it is assumed that the values of α_K and α for the 284-keV transition have errors of ±0.2, then the errors in the intensity ratios become those shown in the lower half of Table I. It is seen that the errors in the intensity ratios are quite insensitive to the errors in α_K and α for the 284-keV transition. Of course, neither ratio is very sensitive to the values of α for the 703- and 987-keV transitions since these numbers are small, being 0.012 and 0.007, respectively[12]—assuming of course that the assignment of $E2$ for each of these transitions is correct.

Using a γ-ray intensity of 63 and a transition intensity of 63.3[9] for the 987.8-keV transition, the γ-ray and transition intensities for the 284- and 703-keV transitions become $G_{284}=7.4\pm0.9$, $G_{703}=11.6\pm3.8$, $I_{284}=11.1\pm1.3$, and $I_{703}=11.8\pm3.9$.

HALF-LIFE MEASUREMENT

The half-life of the isomeric level was measured using the oscilloscope method of Bergstrom *et al.*[13] Measurements were made with the K x ray and also with the 580.0-keV transition announcing the formation of the isomer. The output from a single-channel pulse-height analyzer with its window centered on the photopeak of the 987.8-keV transition was used as the signature of the decay of the isomer. No measurements were made using the 1208.3- or the 1552.2-keV transitions to announce the formation of the isomer because of intensity considerations. The source was placed inside the well crystal for this work.

A standard least-squares analysis of the data gave half-lives of 5.0±0.4 msec and 4.1±0.4 msec which are in reasonable agreement with the previously determined values of 4.8±1.5 msec[7] and 4.0±0.2 msec.[13]

A typical result is seen in Fig. 4. Here the 580.0-keV transition was used to announce the formation of the isomeric level. The error quoted in Fig. 4 was determined

[13] I. Bergstrom *et al.*, Nucl. Instr. Methods 8, 151 (1960).

by the computer on the basis of the least squares fit. An increase in the quoted error by 50% may be necessary to adequately include additional sources of experimental error.

LOCATION OF THE 550.1-keV TRANSITION

Based on the postulate that the 580.0-keV transition feeds the isomeric level, a tentative energy level in ^{205}Pb is established at 1013.8+580.0 or 1593.8 keV. The energy difference 1593.8−1043.7 or 550.1 keV suggests that the intense 550.1-keV transition may go from the 1593.8-keV level to the 1043.7-keV level. Since one of the authors (SHV) had already taken extensive γ-γ coincidence data[14] on the decay of ^{205}Bi using a NaI crystal and a Ge crystal, a search was made through these unpublished data to test the validity of this hypothesis. Figure 5 shows one of several sets of coincidence spectra between the 1043.7-keV transition (as seen by the NaI detector) and other transitions (as seen by the Ge detector). The other coincidence data mentioned above corroborated the result shown in Fig. 5. From this there seems to be little doubt that the 550.1-keV transition does indeed feed the 1043.7-keV level.

If the 550.1-keV transition is $E1$ and the 580.0-keV transition is $E2$ as previous workers[4] have suggested, then the lowest possible spin which the 1043.7-keV level could have would be $\frac{7}{2}$. On the other hand, since the 1043.7-keV level decays to the $\frac{5}{2}^-$ ground state by a $M1$ transition,[1,4] the largest spin which the 1043.7-keV level can have is $\frac{7}{2}$. These two pieces of information would seem to uniquely fix the spin of the 1043.7-keV level as $\frac{7}{2}^-$.

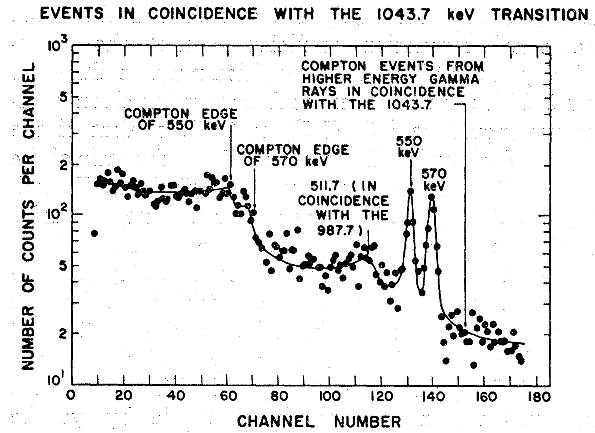

FIG. 5. A spectrum, taken with a Li drifted Ge detector, of the events in prompt coincidence with the 1043.7-keV transition. Photopeaks at 550 and 570 keV are quite evident. These are interpreted as the 550.1- and 570.7-keV transitions.

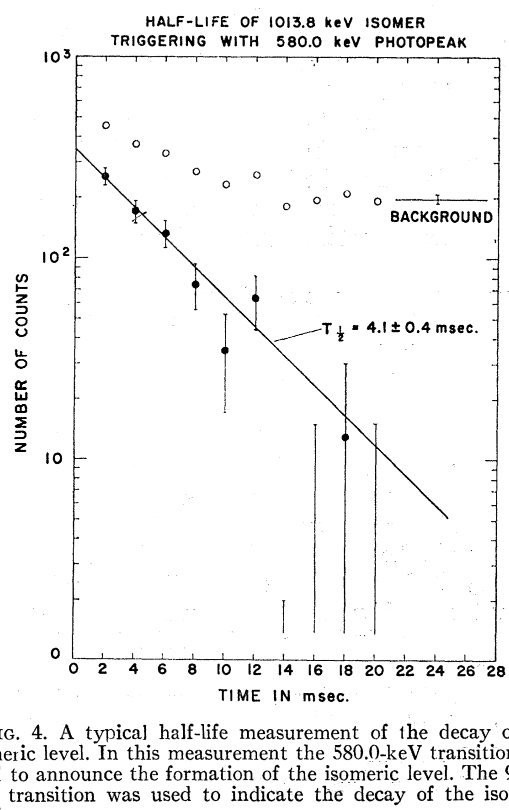

FIG. 4. A typical half-life measurement of the decay of the isomeric level. In this measurement the 580.0-keV transition was used to announce the formation of the isomeric level. The 987.8-keV transition was used to indicate the decay of the isomeric level.

MULTIPOLARITY OF THE 1208.3-keV AND THE 1552.2-keV TRANSITIONS

The γ-ray intensities of the 1208.3- and the 1552.2-keV transitions are 7.6±1.1 and 6.1±0.8 on a scale where the γ-ray intensity of the 703.4-keV transition in the decay of ^{205}Bi is 100. Thus, these results are directly comparable to those of Ref. 9. From the work of Schmorak *et al.*,[1] the intensity of the K conversion electrons for the 1552.2-keV transition is 0.8 relative to a K electron conversion intensity of 100 for the 703.4-keV transition. If the 703.4-keV transition is $E2$ as is generally assumed, its K conversion coefficient is approximately 0.01.[12] With this assumption the K conversion coefficient for the 1552.2-keV transition calculates to be 1.3×10^{-3}. The theoretical values[12] for $E1$, $E2$, $E3$, $M1$ and $M2$ K conversion coefficients for transitions of this energy are, respectively, 1.0×10^{-3}, 2.4×10^{-3}, 4.7×10^{-3}, 4.7×10^{-3}, and 1.1×10^{-2}. Thus the 1552.2-keV transition is most likely $E1$ or $E2$.

From a visual analysis of original β-ray spectrometer plates, reproductions of which are shown in Ref. 9, it can be ascertained that the K conversion electron intensity of the 1208.3-keV transition is much less than that of the 1351.7-keV K electron conversion intensity which in turn is only 1.1/7.6 as strong as that of the 1190.0-keV transition.[9] From an analysis of a singles γ-ray spectrum of ^{205}Bi taken on a Ge detector[14] the relative intensity of the 1208.3-keV γ is found to be about $\frac{1}{3}$ that of the 1190.0-keV γ. Since the 1190.0-keV

[14] S. H. Vegors (to be published).

transition is most likely $M1$ [9] it follows from the theoretical conversion coefficients[12] that the multipolarity of the 1208.3-keV transition must be either $E1$ or $E2$. If it were $E2$, then its K conversion electron intensity should be $\frac{1}{3}(3.4/7.7)$, or 13%, of that of the 1190-keV transition. The ratio 3.4/7.7 is the ratio of the $E2$ to $M1$ K electron conversion coefficients. Thus if the 1208.3 were $E2$, its K electron conversion intensity should be approximately the same as that of the 1351.7-keV transition. Since it is considerably less, the 1208.3-keV transition must be $E1$. If this is so, then the K conversion electron intensity of the 1208.3-keV transition should be approximately $\frac{1}{3}$ of that of the 1351.7-keV transition. Although it is difficult to make an accurate estimate of relative intensities by eye, the relative K electron intensities do not appear to be inconsistent with this assignment, whereas they appear to be inconsistent with all the other possibilities. Therefore, the 1208.3-keV transition is given an $E1$ assignment.

DISCUSSION

From the results presented here it is possible to construct a partial decay scheme for ^{205}Pb. This is shown in Fig. 6. The level at 1043.7 keV has been assigned a spin and parity of $\frac{7}{2}^-$ as previously discussed. The fact that the 550.1-keV transition feeds the 1043.7-keV level and the 580.0-keV transition feeds the 1013.8-keV level, strongly suggest that both of these transitions come from the same level at 1593.8 keV. The assignment of $\frac{9}{2}^+$ for the 1593.8-keV level would seem to be quite firm if the previously assigned multipolarities

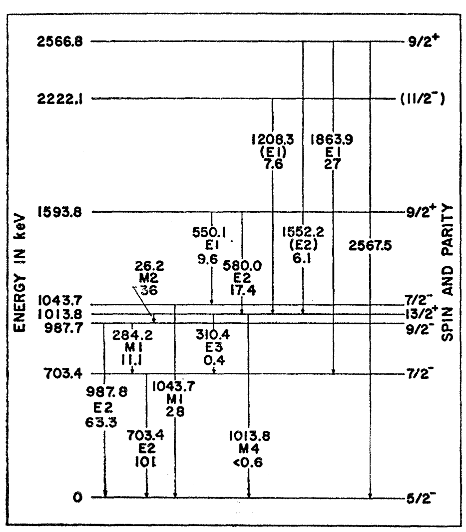

FIG. 6. A partial energy-level diagram for ^{205}Pb incorporating the results of this experiment. The intensities shown here are the transition intensities. The 703.4-keV intensity is its total transition intensity, not just that fraction which comes from the decay of the isomeric level.

of the 550.1-, 580.0-, and 1043.7-keV transitions are correct.

The fact that the 1208.3-keV transition feeds the isomeric level means that there should be an energy level at 2222.1 keV. Assuming that the multipolarity of the 1208.3-keV transition is $E1$, the spin and parity of this level at 2222.1 keV would have to be either $15/2^-$, $13/2^-$, or $11/2^-$. Since there is no evidence for the 1208.3-keV transition being in prompt coincidence with any other γ rays—at least above an energy of 150 keV—it may be tentatively assumed that the energy level at 2222.1 keV is fed directly by K capture. If this is so, a spin and parity assignment of $11/2^-$ for this level would seem to be the most reasonable. With this assignment the 2222.1-keV level would be fed by an allowed transition, whereas a $13/2^-$ or a $15/2^-$ level would have to be fed by a second parity forbidden, or a second unique forbidden transition, respectively.

The energy sum 1552.2 keV+1013.8 keV implies a level at 2566.0 keV. From previous work,[1,4,8,9] a $\frac{9}{2}^+$ level at 2567.4 keV is well established. Considering the fact that the 1552.2-keV transition is most likely either $E1$ or $E2$, it seems quite probable that the previously established level at 2567.4 keV and the implied level at 2566.0 keV may actually be the same. The energy discrepancy of 1.4 keV is within the experimental accuracy of the energies of the transitions. Thus the assumption will be made that the 1552.2-keV transition comes from the previously determined energy level at 2567.4 keV. An average of the reported energies for this level,[1,4,8,9] together with the results of the present work, suggest an energy of 2566.8 keV for this level. If $\frac{9}{2}^+$ is the correct spin assignment for the 2566.8-keV level, the 1552.2-keV transition should be $E2$. Considering possible errors in the K electron conversion intensity[1] it is felt that this assignment is not inconsistent with the experimental data.

A search was made to see if any other previously detected transitions in the decay of ^{205}Bi might fit between established levels[9] and the new levels postulated here. This was done by comparing the magniude of the difference in energy between the two new levels reported here at 1593.8 and 2222.1 keV and all the levels in Ref. 9 with the transition energies listed in Ref. 9. Other than the 550.1-keV transition no agreement was found which would cause the relocation of any of the transitions in the energy-level diagram in Ref. 9.

Finally, it should be noted that True[15] predicts a $\frac{9}{2}^+$ level at 1769 keV and $11/2^-$ levels at 1778 and 2476 keV. Pryce[16] predicts $\frac{9}{2}^+$ levels at 2.1 and 2.5 MeV and a $11/2^-$ level at 1.8 MeV. It would therefore seem that the results of this work are in better accord with True for the $\frac{9}{2}^+$ level but with Pryce for the $11/2^-$ level.

[15] W. W. True, Nucl. Phys. 25, 155 (1961).
[16] M. H. L. Pryce, Nucl. Phys. 2, 226 (1956).