the product wave functions without substracting the center-of-mass coordinate, we could make the following prescription to eliminate spurious states.[8] A state with the proper center-of-mass motion can be written as

$$\Psi(\gamma_1,\gamma_2\cdots\gamma_A)=e^{-\nu A\xi_0^2}\Phi_{\rm int}(\xi_1\cdots\xi_{A-1}).$$

Before we proceed to do our calculations with our original wave function, we could transform it into the new system and verify whether the center-of-mass wave function has the desired form. The above prescription can be shown to be identical to that of Elliott and Skyrme.[2]

If we had started with a potential energy in the more natural form $k\sum_{i=1}^{A}(\gamma_i-\mathbf{R})^2$, where R is the center of mass, the center-of-mass Hamiltonian would consist only of the kinetic-energy term and all the other features would still remain the same.

In a more realistic calculation, if the average potential is quite close to a harmonic-oscillator potential, one could make a perturbation approach, studying the variation of energy due to a perturbation of the harmonic-oscillator potential. This method was suggested to the author by Professor R. M. Thaler. Some calculations using this approach are being done presently.

ACKNOWLEDGMENTS

The author expresses his appreciation to Professor R. M. Thaler and Dr. R. E. Schenter for several interesting comments and suggestions during the course of this work. The author also wishes to express his gratitude to Professor B. F. Bayman for pointing out the simplification in the perturbation calculation.

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Decay of Rb^{90}

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Following the neutron irradiation of uranyl stearate, Rb^{90} sources were prepared by milking from the emanated Kr^{90}. The decay properties of Rb^{90} were then investigated with scintillation techniques. From single-crystal and gamma-gamma coincidence spectra, gamma rays (and intensities) were found at energies of 0.53(6.6), 0.72(6.5), 0.832(90), 0.86(10), 1.03(6.0), 1.11(13), 1.24(4.3), 1.40(8.3), 1.70(6.1), 1.82(4.8), 2.20(3.6), 2.51(5.6), 2.72(1.8), 2.84(3.0), 3.07(9.7), 3.34(28), 3.54(12), 4.13(20), 4.34(24), 4.37(7.8), 4.60(8.4), 5.08(3.0), and 5.23(6.7) MeV. Also, from single-crystal and beta-gamma coincidence spectra, beta-ray groups were observed with energies of 1.31, 2.0, 2.2 (complex), 4.37, 5.81, and 6.60 MeV, where the last group represents the separation between the Rb^{90}-Sr^{90} ground states. The decay scheme proposed for Rb^{90} involves levels in Sr^{90} at 0.832, 1.69, 1.94, 2.23, 3.07, 3.34, 4.15, 4.34, 4.60, 5.08, and 5.23 MeV. The half-lives of Rb^{90} and Rb^{91} have been remeasured as 2.91±0.05 min and 1.17±0.10 min, respectively.

I. INTRODUCTION

As part of a program of surveying the properties of several nuclear families of constant Z, we have previously studied[1,2] the levels of Sr^{88} and Sr^{89}. This effort has now been extended to the nucleus Sr^{90} by observing the decay radiations from Rb^{90}.

The nucleus Rb^{90} was first characterized by Kofoed-Hansen and Nielsen.[3] They swept the rare gases from a neutron-irradiated uranium solution into a magnetic isotope separator. By separating Kr^{90} and allowing it to decay, they produced an essentially pure Rb^{90} sample. They reported a 2.74-min half-life and a maximum beta-ray end-point energy of 5.7 MeV as determined by aluminum absorption. Wahlgren[4] also observed Rb^{90} in his study of Kr^{90}.

We have utilized beta- and gamma-ray scintillation techniques in our investigation of the Rb^{90} decay. A preliminary report of the present work has appeared earlier.[5]

II. SOURCE PREPARATION AND HALF-LIFE DETERMINATION

The Rb^{90} sources were obtained by decay of the rare-gas parent, 33-sec Kr^{90}, which was emanated from a neutron-irradiated uranium sample. The experimental

* Operated by the Union Carbide Corporation, Nuclear Division, for the U. S. Atomic Energy Commission.

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[4] M. A. Wahlgren, TID-11807, Office of Technical Services, Department of Commerce, Washington 25, D. C., 1961 (unpublished).

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method was analogous to that utilized in the study of Rb^{89} described earlier,[2] but differed in two important details. First, uranyl stearate was used as the fissioning sample. This compound has the property of releasing the rare gases rapidly and quantitatively (see Wahl and Daniels[6]). Second, a krypton-xenon separation was performed using gas chromatography.

The procedure is illustrated by Fig. 1. Approximately one gram of natural uranium as uranyl stearate was placed in a pneumatic tube "rabbit" fitted with a gas cell (see Ref. 7 for details of gas cell and transfer technique). The sample was irradiated for approximately 30 sec in the Oak Ridge graphite reactor. After ejection of the rabbit from the reactor, a 30-sec waiting period was interposed to allow decay of the 10-sec Kr^{91} (as well as the heavier krypton isotopes). Then the transfer needle was inserted into the gas cell, and the emanated rare gases were swept out under the −70-mm "off-gas" vacuum. The gas stream passed through the glass wool trap for removal of halogens, which were emanated in small quantities by the uranyl stearate. Next, the gases encountered the cooled charcoal trap on which they were adsorbed. Xenon is strongly adsorbed at 0°C and will remain on such a trap indefinitely; however, krypton is only weakly adsorbed. The breakthrough of the krypton was observed with the scintillation counter. When the krypton "peak" had passed the counter and entered the collection cell, the stopcocks were closed. A potential of −400 V was applied to a thin Al foil suspended in the collection cell, and the Rb^{90} ions were collected following beta decay of Kr^{90}. For gamma-ray sources, the collecting foils were 0.25-mil Al, mounted between layers of 1-mil Mylar adhesive tape. Sources for beta-ray spectrometry were prepared by collecting the Rb^{90} ions on 0.1-mg cm^{-2} Al leaf; segments of the Al leaf strip then were mounted on the 1-mil Mylar tape without a cover. For 4π counting, the segments of 0.1-mg cm^{-2} Al leaf were mounted between laminated Formvar-Polystyrene films of about 50 $\mu g\ cm^{-2}$. The usual collection time was 30 sec; thus, the total time from the end of the bombardment was 90 sec.

Bombardment, delay, and collection times were varied to obtain optimum conditions. Those times mentioned above gave the best ratio of Rb^{90} to Rb^{89} with essentially complete rejection of Rb^{91} (see below).

The beta-decay of a source of Rb^{90} produced as described above was followed for over two hours with an end window proportional counter; the data were analyzed with a computer least-squares program. The half-life observed for Rb^{90} was 2.91±0.05 min; a long-lived tail was also present with a half-life of 14.9 min, the value previously[2] obtained for Rb^{89}. Using a 4π beta proportional counter, the same half-life as above was obtained for Rb^{90}. The decay of the 0.832- and 1.40-MeV gamma rays gave half-life values of 3.0±0.1 and 2.7±0.2 min, respectively.

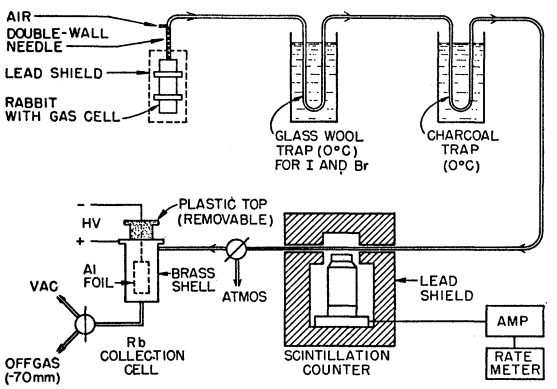

FIG. 1. Diagram illustrating preparation of Rb^{90} sources.

A source preparation was performed in which the waiting period before gas sweeping was eliminated. Thus, Kr^{91} was present in the collection cell. The beta decay of this source revealed a 1.17±0.10-min group which agrees well with the 1.2±0.1-min period observed by Wahl, *et al.*[8] and Wahlgren[4] for Rb^{91}. From the beta-decay results of the runs with and without the waiting period, we were able to infer that the samples used for the Rb^{90} experiments contained $<5\%$ Rb^{91}. In addition, Wahlgren's work indicates that the only intense gamma rays from Rb^{91} decay are under 0.50 MeV in energy.

III. GAMMA-RAY SPECTROMETRY

The gamma-ray spectra were measured with 3-in.×3-in. cylindrical NaI crystals mounted on Dumont 6363 photomultiplier tubes. Polystyrene absorbers (3.34 g/cm^2) were placed between the source and the crystal in order to stop the energetic beta rays. Both 20- and 256-channel analyzers were used for the pulse-height measurements. The pulse-height resolution for the system was 7.8% for the 662-keV gamma ray of Cs^{137}.

A Rb^{90} single-crystal gamma-ray spectrum (corrected for 14.9-min Rb^{89} contribution) is shown in Fig. 2. Since no obvious structure is apparent below 0.50 MeV, no attempt was made to study this region of the spectrum. Spectral analysis was done by the successive subtraction of full-energy peaks and Compton distributions. The shapes used for this analysis were determined from standards measured under similar experimental conditions. The peak at 0.832 MeV is considerably broader than that expected for a single transition at this energy, thus indicating that it is composed of more than one gamma ray. Indeed, the coincidence measurements show that there is at least one other gamma ray (0.86 MeV) here and also that the peaks at 3.34 and 4.34 MeV are likewise complex. The broad distribution at

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[8] A. C. Wahl, R. L. Ferguson, D. R. Nethaway, D. E. Troutner, and K. Wolfsberg, Phys. Rev. **126**, 1112 (1962).

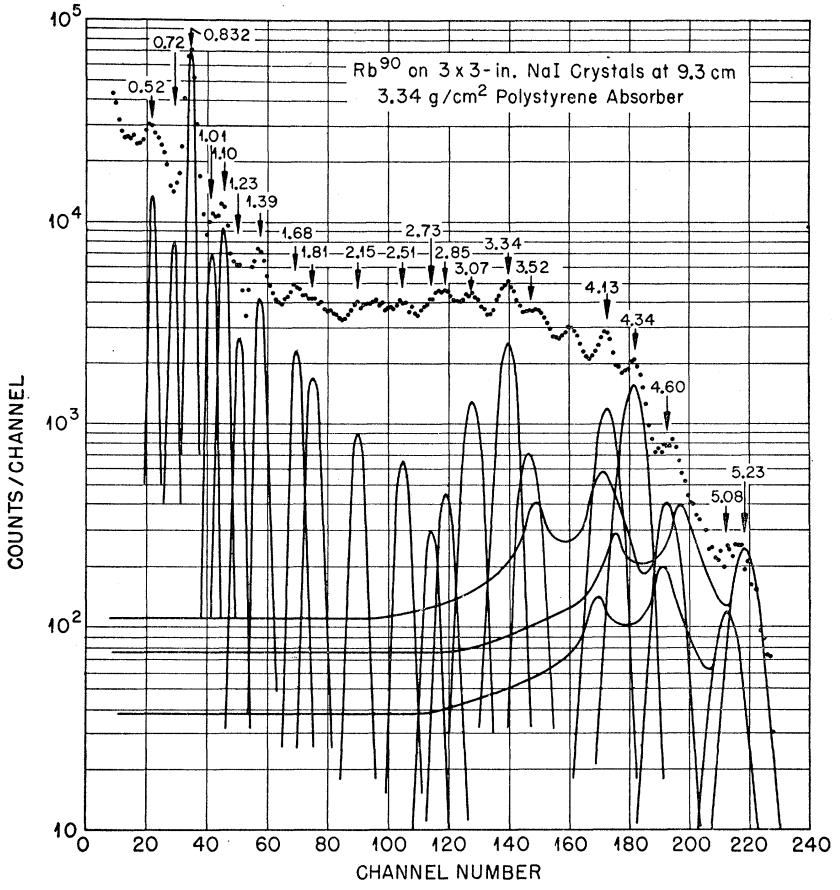

FIG. 2. Single-crystal gamma-ray spectrum of Rb^{90}. The data have been corrected for the 14.9-min Rb^{89} contribution.

0.50 MeV indicates there are perhaps several gamma rays at about this energy although much of the intensity here (as in all the other gamma-ray spectra) is probably due to pairs produced in the surrounding lead shield by the energetic gamma rays. In Table I are listed the single-crystal gamma-ray intensities relative to 100 units of intensity for all of the transitions centered at 0.832 MeV. Note that the energies shown in this table are not necessarily those given in Fig. 2, but are the best values as determined from both single-crystal and coincidence measurements.

TABLE I. Summary of Rb^{90} gamma-ray data.

E_γ,[a] MeV	Single crystal intensity	Coincidence quotient with gamma rays of energy (MeV): 0.832	1.11	3.34
0.53 ±0.02[b]	6.6 ±3.3	0.077 ±0.030	weak[e]	0.11 ±0.06[f]
0.72 ±0.03	6.5 ±3.0	0.04 ±0.02		
0.832 ±0.012	100	0.20 ±0.03[c]	very strong	0.57 ±0.15
0.86 ±0.03				
1.03 ±0.05	8.5 ±2.2	0.089 ±0.015	very weak	0.22 ±0.08
1.11 ±0.03	13.2 ±3.0	0.11 ±0.02		
1.24 ±0.02	4.3 ±1.5	0.057 ±0.010	strong	
1.40 ±0.02	8.3 ±1.5	0.079 ±0.010		
1.70 ±0.04	6.1 ±2.0	0.062 ±0.012		
1.82 ±0.04	4.8 ±2.0	0.038 ±0.015		
2.20 ±0.04	3.6 ±1.5	0.045 ±0.015	weak	
2.51 ±0.04	3.4 ±1.5	0.056 ±0.015		
2.72 ±0.05	1.8 ±1.0	0.059 ±0.025		
2.84 ±0.04	3.0 ±1.4	0.065 ±0.020		
3.07 ±0.05	9.7 ±3.5			
3.34 ±0.04[d]	27.5 ±4.5	0.16 ±0.03	strong	
3.54 ±0.05	8.1 ±4.0	0.12 ±0.02		
4.13 ±0.05	19.6 ±4.0			
4.34 ±0.05	31.3 ±6.0	0.078 ±0.030		
4.37 ±0.05				
4.60 ±0.05	8.4 ±2.0			
5.08 ±0.07	3.0 ±1.3			
5.23 ±0.06	6.7 ±2.3			

[a] These are the best energy values as deduced from all the experiments.
[b] There are probably several transitions with about this energy.
[c] The coincident peak position is at 0.848 MeV. See text for a discussion of this aspect.
[d] There are two transitions with this energy.
[e] Very broad distribution centered at 0.55 MeV.
[f] Very broad distribution centered at 0.5 MeV.

For the gamma coincidence measurements, the source was placed at the center of a collimating anti-Compton shield to reduce the effects arising from Compton scattering. The source was viewed by two 3-in.×3-in. NaI crystals mounted at 180° to each other. The "fast-slow" coincidence circuit had a resolving time of 0.19 μsec.

Figure 3 shows the spectrum in coincidence with a 92-keV window centered at 0.832 MeV. Both the Rb^{89} coincidence contribution and the chance coincidences have been removed from this spectrum. One of the more interesting aspects of Fig. 3 is the 0.848-MeV peak which is much broader than that for a single gamma ray. This seems a clear indication that the intense peak at 0.832 MeV in the single-crystal spectrum is composed of more than one gamma-ray transition of about that energy and that a coincidence relationship exists between these transitions. It is not possible here to accurately assess the number of different gamma-ray transitions in-

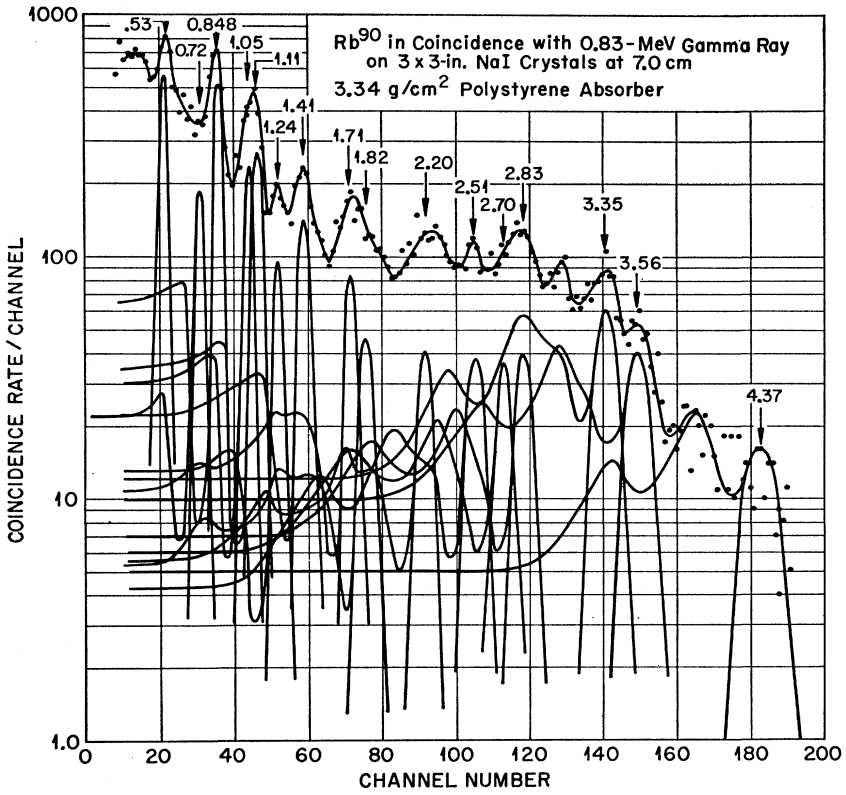

FIG. 3. Rb^{90} gamma-ray spectrum in coincidence with a 92-keV window set at 0.83 MeV. The data have been corrected for both the Rb^{90} coincidence contribution and the chance coincidences.

volved in this peak, but the data analysis has been performed as if it were composed of a 0.832-MeV gamma ray and another at about 0.86 MeV (see Table I). "Coincidence quotients" q for the gamma rays in this spectrum are shown in Table I. The "coincidence quotient" is defined as the ratio of the number of coincident gamma rays of interest to the number of "gating" gamma rays in the single-channel window. Complete details on the methods of calculation are given elsewhere.[9,10]

In Fig. 4, we show the spectrum in coincidence with the single-channel window (106 keV wide) set at 1.11 MeV. There are two problems associated with the interpretation of this spectrum. First, it is difficult to accurately determine the amount of the 1.03-MeV gamma ray included in the window. But more important is the fact that the most intense gamma peak in the Rb^{89} spectrum is at 1.05 MeV, and in the present experiment, a very large fraction of the counts in the window—and, in turn, in the gross coincidence spectrum —are due to Rb^{89}. Accordingly, a small error in subtracting the Rb^{89} coincidence contribution leads to rather large errors in the q values calculated for this run. Thus, only qualitative indications of these coincidence intensities are shown in Table I.

With a 245-keV-wide window centered at 3.34 MeV, the spectrum of Fig. 5 was obtained. The effects of chance coincidences and long-lived background have been subtracted. The q values obtained here show that only part of the 3.34-MeV gamma rays are in coinci-

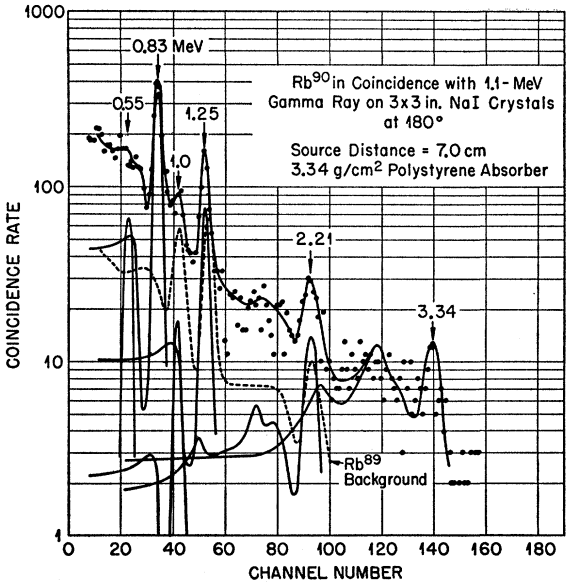

FIG. 4. Gamma-ray spectrum coincident with a 106-keV window centered on the 1.11-MeV gamma-ray peak of Rb^{90}. The chance-coincidence contribution has been removed.

[9] N. R. Johnson, E. Eichler, G. D. O'Kelley, J. W. Chase, and J. T. Wasson, Phys. Rev. **122**, 1546 (1961).
[10] E. Eichler, G. D. O'Kelley, R. L. Robinson, J. A. Marinsky, and N. R. Johnson, Nucl. Phys. **35**, 625 (1962).

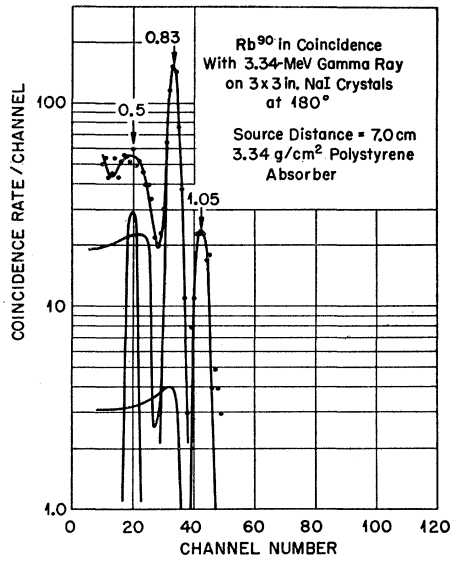

FIG. 5. Rb^{90} gamma-ray spectrum in coincidence with a 245-keV window centered at 3.34 MeV. The chance coincidence and Rb^{89} coincidence background effects have been subtracted.

dence with the 0.832-MeV transition in agreement with the results of Fig. 3.

In one further experiment, no gamma rays were observed in coincidence with the 5.23-MeV peak, thus indicating a ground-state transition of this energy.

IV. BETA-RAY SPECTROMETRY

Beta-ray spectra were measured with a $1\frac{1}{4}$-in.$\times$1-in. cylindrical anthracene crystal. The crystal was attached to a Dumont 6292 photomultiplier tube and was completely surrounded by a specular reflector (aluminized mylar foil of 1 mg/cm² surface density). The pulse-height resolution of this system was $\sim$14% for the 624-keV conversion-electron line of Ba^{137m}.

The Fermi plot of a single-crystal beta-ray spectrum shown in Fig. 6 indicates a weak distribution extending out to 7.5 MeV. It was found that by varying the counting rate, both the intensity and the end point of this "pseudo-beta group" could be altered. This is a pattern of behavior expected from randomly summed events. (Resolution distortion corrections can eliminate only a small part of this difficulty beyond the maximum real-beta group.) In the analysis of the data in Fig. 6, the pseudobeta group was subtracted as if it were a real component. This procedure appears satisfactory for obtaining the end points of the two most energetic beta rays in Rb^{90}, as is substantiated in the coincidence experiments described below.

For a more careful study of the lower energy beta-ray groups, "beta-gamma" coincidence experiments were performed by gating on some of the more prominent portions of the gamma-ray spectrum. The gamma-ray detector was a 3-in.$\times$3-in. NaI crystal shadowed by a 3.34 g/cm² polystyrene beta-ray absorber. The beta-ray detector was once again the $1\frac{1}{4}$-in. $\times$1-in. anthracene crystal, and the "fast-slow" coincidence circuit was the same as that employed in the gamma-gamma experiments.

In Fig. 7 is shown the Fermi plot of the coincidence data obtained with a 92-keV window centered on the gamma-ray peak at 0.832 MeV. The observation of the beta-ray group at 5.81$\pm$0.10 MeV is consistent with the assumption that the 6.60-MeV group feeds the ground state of Sr^{90}, that the 0.832-MeV gamma ray depopulates the first excited level, and that this 5.81-MeV group feeds the 0.832-MeV level (see the decay scheme in Fig. 9).

In Fig. 8, we show Fermi plots of the beta rays coincident with all gamma rays above various discriminator settings of the single-channel analyzer. Although such a procedure is usually not as desirable as gating on specific gamma-ray full-energy peaks (cf. Fig. 7), it enables one to achieve acceptable counting statistics within a reasonable time.

Figure 8(a) shows the results for the discriminator bias set to accept all gamma rays with energies greater than 3.1 MeV. The highest energy beta ray observed here is at 3.25$\pm$0.15 MeV. The only other group analyzed in this spectrum is at 2.3$\pm$0.2 MeV. This latter group is probably complex, actually consisting of two beta-ray groups feeding levels at 4.15 and 4.34 MeV in Sr^{90} (see decay scheme of Fig. 9).

When the discriminator was set to accept gamma rays greater than 3.8 MeV, the data for Fig. 8(b) were obtained. As is thought to be the case for the inner group of Fig. 8(a), the 2.3-MeV group here is probably complex, resulting primarily from beta rays coincident with 4.13- and 4.34-MeV gamma rays.

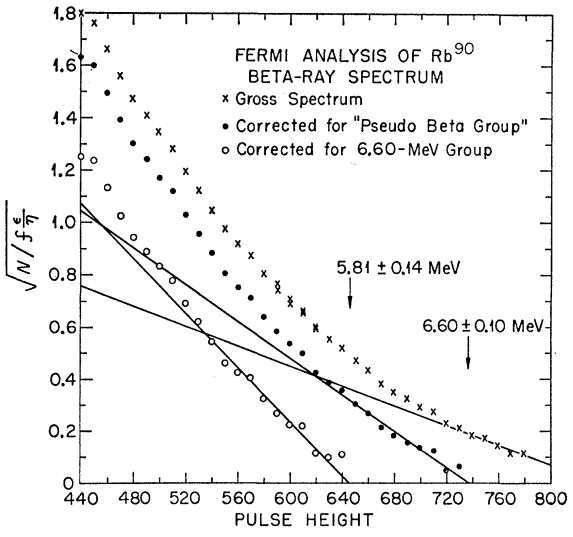

FIG. 6. Fermi analysis of Rb^{90} single-crystal ($1\frac{1}{4}$-in.$\times$1 in. anthracene) beta-ray spectrum. The high-energy distribution extending out to 7.5 MeV is a pseudobeta group which results from summing.

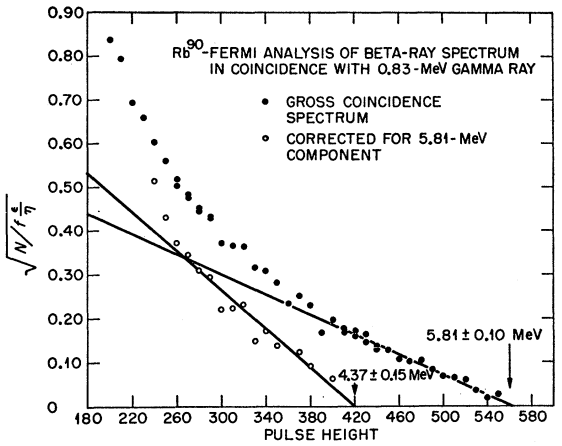

FIG. 7. Fermi analysis of coincidence data obtained with a 92-keV window centered on the gamma-ray peak at 0.832 MeV.

By moving the discriminator bias to 4.2 MeV, the ratios of the gating gamma rays is further changed. The effect on the coincident beta spectrum is to enhance a group at 2.0±0.1 MeV, as is shown in Fig. 8(c). It appears that a component greater than 2.0 MeV may also be present in low intensity. This component probably arises from a small number of 4.34-MeV gamma-ray events which were accepted at this bias setting.

When the single-channel analyzer was set to accept gamma rays >4.9 MeV, the results of Fig. 8(d) were obtained. The 1.31-MeV beta ray observed here probably is due to a coincidence with the 5.23-MeV gamma ray which is responsible for most of the gating events.

Other coincidence experiments were also performed in which portions of the beta spectrum with energies >4.2 MeV were accepted by the single-channel analyzer and the coincident gamma spectrum was displayed on the multichannel analyzer. The only pronounced feature observed in these was a gamma-ray peak at 0.84 MeV.

TABLE II. Intensities and comparative half-lives of Rb^{90} beta-ray transitions (beta-ray subscripts denote final states).

Beta-ray group	Experimental energies, MeV	Intensity	Logft
β_0	6.60±0.10	a	>6.9
$\beta_{0.83}$	5.81±0.10	0.10±0.03	7.6
$\beta_{1.69}$		0.06±0.02	7.5
$\beta_{1.94}$		0.05±0.02	7.5
$\beta_{2.23}$	4.37±0.20	0.05±0.02	7.3
$\beta_{3.07}$		0.06±0.02	7.0
$\beta_{3.34}$		0.07±0.03	6.8
$\beta_{4.15}$	2.2 ±0.2	0.23±0.05	5.6
$\beta_{4.34}$		0.17±0.04	5.7
$\beta_{4.60}$	2.0 ±0.1	0.05±0.01	6.0
$\beta_{5.08}$		0.02±0.01	6.0
$\beta_{5.23}$	1.31±0.14	0.08±0.01	5.1

[a] The ground-state beta-ray intensity is determined by the difference between the total beta disintegration rate and that to the excited states. In the present case, the ground-state branch is obviously quite weak, and so it is not possible to reliably assign its intensity since there are large limits of error associated with the intensities of most of the beta rays feeding excited states.

In order to determine the absolute beta-ray branching to Sr^{90} levels, the number of 0.832-MeV gamma rays per Rb^{90} disintegration was measured using a gamma scintillation spectrometer simultaneously with a 4π beta proportional counter. After the data were corrected for long-lived background contributions, the number of 0.832-MeV gamma transitions per disintegration was found to be 0.56. From the decay scheme of Fig. 9 and the gamma-ray intensities, it is then possible to compute the absolute beta-ray intensities. A summary of the results is shown in Table II. It will be noted that the beta-ray intensities of Table II have rather large limits of error. This is, first of all, a reflection of the errors associ-

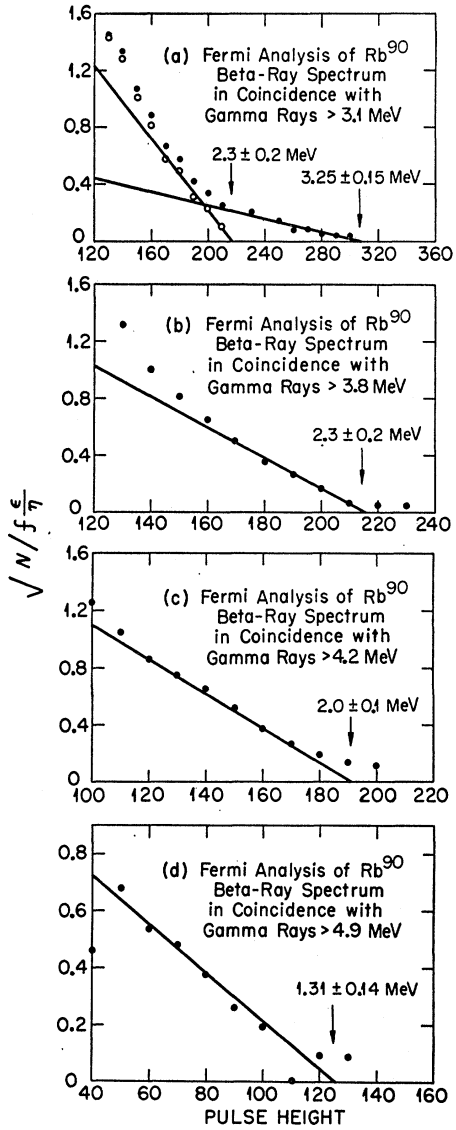

FIG. 8. Fermi analyses of coincident beta-ray spectra when the single-channel analyzer was allowed to gate on all gamma rays with energies above discriminator settings of: (a) 3.1 MeV, (b) 3.8 MeV, (c) 4.2 MeV, and (d) 4.9 MeV.

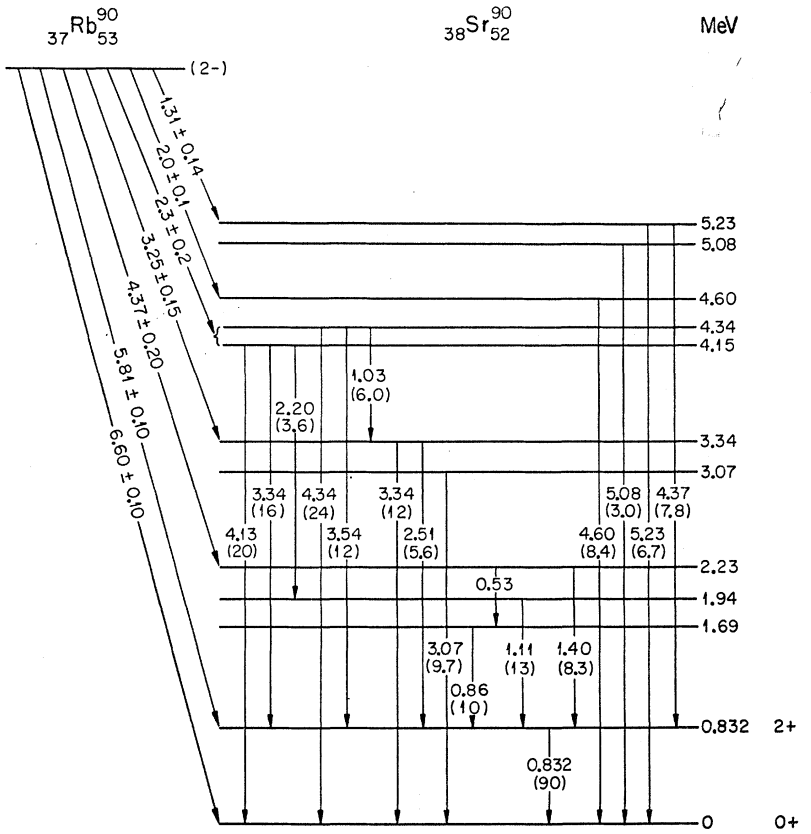

FIG. 9. Partial decay scheme proposed for Rb^{90}. All energies are in MeV. Relative intensities based on the single-crystal and coincidence data are given in parentheses beneath the gamma-ray energies.

ated with the gamma-ray intensities. In addition, the contributions of gamma rays below about 0.5 MeV have been neglected with one exception, and can thus lead to an additional error in the present determination of beta-ray intensities.

V. DISCUSSION

Many of the arguments for the decay scheme in Fig. 9 have already been presented, and others will be given below. It should be emphasized that although many features of this scheme are well supported by the experimental data, there are some aspects where the data permit alternate interpretations. The scheme of Fig. 9 does, however, appear to be consistent with all of the prominent features of the experimental measurements reported above. The energies and intensities used in the scheme are the best values determined from both the single-crystal and coincidence experiments.

The 6.60-MeV beta ray is assigned as the ground-state transition for several reasons. In the first place, it did not appear in any of the "beta-gamma" coincidence results. Secondly, the 5.23-MeV gamma ray was found to be in coincidence with none of the gamma transitions, but only with a 1.31-MeV beta group, and this is consistent with a total Rb^{90}-Sr^{90} energy separation of about 6.6 MeV. Finally, using available mass predictions[11,12] and beta systematics,[13] one would predict approximately this energy for the ground-state decay.

If it is accepted that the 6.60-MeV beta ray populates the ground state of Sr^{90}, then the observation of a 5.81-MeV beta ray in coincidence with the 0.832-MeV gamma peak establishes the first excited level at 0.832 MeV. This is further supported by observation of a 0.84-MeV gamma ray in coincidence with beta rays >4.2 MeV, as well as by arguments based on the single-crystal and coincidence intensities of Table I.

Assignment of the second excited Sr^{90} level at 1.69 MeV is based only on the spectrum coincident with the 0.832-MeV gamma-ray peak. In this experiment, the energy of the coincident peak was 0.848 MeV, and as has already been pointed out, the data analysis was based on the somewhat tenuous assumption that this peak involved only two gamma-ray transitions. It is known that when two coincident gamma rays of very similar energies are included in the single-channel window, the peak observed in the coincidence spectrum is somewhat broadened over that expected for a single component,

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and if the window is centered between the two gamma rays, the energy of the coincident peak position is the mean value of the two transitions involved. Further, the intensity of the upper of the two transitions in the decay scheme is just one-half that indicated by the observed coincidence quotient. In the present case, this has led to an energy assignment of 0.86 MeV for the upper transition and an intensity of 10 units relative to 100 units for the sum of their intensities. It is true that the above interpretations do not demand that the 0.86-MeV transition cascade directly into the 0.832-MeV level, but since none of the experimental information indicates otherwise, it is assigned as decaying from a level at 1.69 MeV.

The results of gating on the 0.832-MeV gamma-ray peak indicate that all of the 1.11-MeV gamma rays cascade via the 0.832-MeV level. When the 1.11-MeV gamma ray gates the analyzer, a similar conclusion is indicated. In light of the other features of the decay scheme to be discussed below, the most reasonable assignment of this transition seems to be decay from a state at 1.94 MeV.

The level at 2.23 MeV is based primarily on the observation of a 4.37-MeV beta ray in coincidence with the 0.832-MeV gamma-ray peak. A level at 3.07 MeV is assigned because the 3.07-MeV gamma ray seen in the single-crystal measurements was not observed in any of the coincidence experiments and is, therefore, assumed to go to the ground state.

An examination of Table I for the singles intensities and coincidence relationship of the 0.832- and 3.34-MeV gamma rays reveals the strong probability of a 3.34-MeV ground-state transition as well as for a 3.34-MeV gamma ray cascading into the 0.832-MeV level. The latter aspect, coupled with the fact that the data of Table I indicate a 4.13-MeV ground-state transition, are compatible with Sr^{90} levels at about 3.34 and 4.15 MeV. As already pointed out in Sec. IV, the beta-gamma coincidence data further support the assignment of these two states in Sr^{90}. The levels at 4.34 and 4.60 MeV are assigned by similar reasoning.

With the single-channel analyzer accepting gamma-ray pulses >4.9 MeV, a 1.31-MeV beta group was seen in the coincidence spectrum. This is an indication of a level at about 5.2–5.3 MeV. More accurately, this level is established as 5.23 MeV on the basis of a ground-state gamma-ray transition of that energy and of coincidences between the 0.832-MeV peak and another gamma ray of 4.37-MeV energy. The gamma-ray data indicate a 5.08-MeV ground-state transition and, consequently, a level of that energy.

The gamma rays at 0.72, 1.24, 1.70, 1.82, 2.72, and 2.84 MeV also appear to belong to the decay of Rb^{90}. However, the present experiments are not sufficient to show their relationship to the decay scheme of Fig. 9. Further, it must be stressed that the nature of the low-energy region of the gamma-ray spectrum has not been examined in this present work. It is almost certainly very complicated, as numerous low-energy transitions are to be expected in so complex a level scheme. Obviously, much more extensive coincidence measurements are necessary in order to give a more complete picture of the properties of the Sr^{90} levels.

From the log ft values in Table II and the spin assignments for the nuclei in the region of Rb^{90}, one may infer that the ground-state spin of Rb^{90} is $2-$. The ground-state spin of Sr^{90} is $0+$ and the first excited level at 0.832 MeV is expected to be $2+$. Beyond this, it is possible to say only that those levels fed by direct beta decay probably have $I \leq 4$.

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