three times its average value in the deuteron. It seems possible that the backward peak would be reduced by the inclusion of tensor forces.[4]

* Assisted in part by the AEC.

[1] G. F. Chew, Phys. Rev. **74**, 809 (1948); R. L. Gluckstern and H. A. Bethe, Phys. Rev. **81**, 761 (1951).

[2] This approximation was checked by calculating the exact and approximate expressions using a Yukawa well and various energies and angles in the range of interest. At 90 Mev the agreement was everywhere within 10 percent; for large angles with higher energies the agreement is rather worse but since the exchange parts of U and L are dominant only for intermediate angles the approximation is satisfactory. We wish to thank Mr. T. A. Auerbach for making available to us his numerical evaluations for the exact integrals.

[3] M. O. Stern, University of California Radiation Laboratory Report No. 1440 (1951) (95-Mev data); Cassels, Stafford, and Pickavance, Nature **168**, 556 (1951) (146-Mev data); R. D. Schamberger, Phys. Rev. **83**, 1276 (1951) (240-Mev data).

[4] Horie, Tamura, and Yoshida, Prog. Theoret. Phys. **6**, 623 (1951).

Some Polystyrene Solid Solutions as Scintillation Counters*

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THE scintillation efficiency and the spectral emission of a number of polystyrene solid solutions have been investigated. The method of preparing the solid solutions and the experimental procedure used in obtaining the data is similar to what has been reported previously.[1] A 5819 photomultiplier tube was used for the counting experiments. Co^{60} was used as a γ-ray source. A commercial x-ray machine was used as a source for the emission-spectra studies. The solid solutions compared were plastic disks containing 2 percent by weight of the phosphor in styrene, which were then polymerized by a 50-50 benzoyl peroxide-tricresyl phosphate catalyst. The results are summarized in Fig. 1 which gives the relative counting rates as a function of discriminator bias and in Table I where the peaks of the emission bands are recorded. It is interesting to compare these results with those obtained with the single crystals of the corresponding phosphors.[2] It will be noted that the relative order is not always the same. A notable exception is diphenylacetylene. In the crystalline state this material compares favorably with stilbene whereas in the solid solution its performance is much poorer. Since the emission bands of the solid solution and of the crystal are located in approximately the same spectral region, a poorer counting rate cannot be ascribed to a shifting away from the region of more favorable spectral response of the 5819 photomultiplier tube.

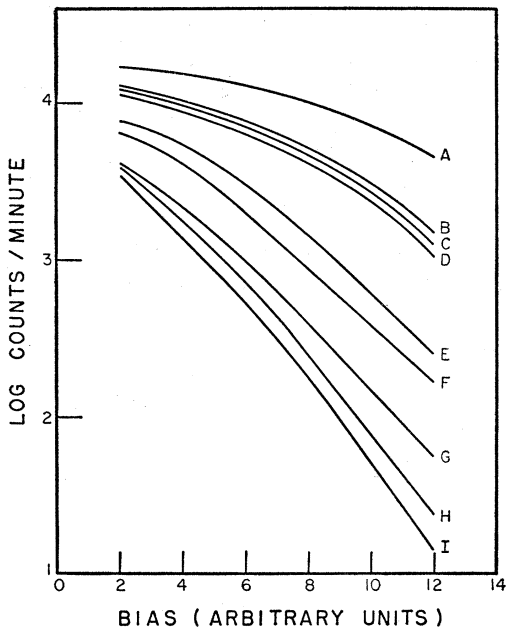

FIG. 1. Discriminator curves for some phosphor-plastic combinations: *A*—terphenyl; *B*—diphenylbutadiene; *C*—anthracene, *D*—stilbene; *E*—diphenyldiacetylene; *F*—biphenyl; *G*—diphenylacetylene; *H*—diphenylethane; *I*—polystyrene (plain).

TABLE I. Wavelengths of emission bands of various 2 percent phosphor-plastic systems excited by x-rays.

Material	Wavelength (A)
stilbene	3760, 3600
diphenylbutadiene	4040
diphenylhexatriene	4200
diphenylacetylene	3720
diphenyldiacetylene	4610
anthracene	4475, 4235
diphenylethane	~3200
terphenyl	3620, 3480

Polystyrene-diphenylhexatriene solid solutions gave poor performances as counters. The large spectral shift toward the blue (1000A), plus the fact that there was a considerable amount of difficulty in realizing the polymerization of the solution, indicated that there probably was a chemical reaction between phosphor and catalyst or styrene with an interruption to the conjugation of the polyene chain. The corresponding system with diphenyloctatetraene failed to polymerize satisfactorily even after prolonged heating so it is not included in these results.

We wish to acknowledge our indebtedness to Professor J. D. H. Donnay and Professor R. Maddin for the use of their x-ray machines.

* This work was performed under the auspices of the AEC.

[1] W. S. Koski, Phys. Rev. **82**, 230 (1951).

[2] W. S. Koski and C. O. Thomas, J. Chem. Phys. **19**, 1286 (1951).

Absence of Secondary Maxima in the Transition Curve for Electronic Showers

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IN a recent letter Tsai-Chü[1] tentatively explained the existence of a secondary maximum of the Rossi curve obtained by a counter arrangement very similar to that of Bothe and Thurin.[2]

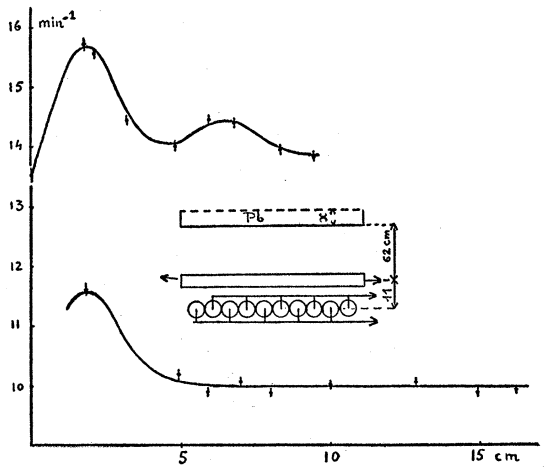

FIG. 1. Rossi curves for lead.

This experiment, the result of which was previously published,[3] does not show any maximum at 15 cm Pb or more, but indicates a small maximum at 7 cm.

I have repeated the experiment as described[3] and have reached the conclusion that this maximum at 7 cm Pb was due to statistical or other fluctuations, and should not be considered. As an effect like the one mentioned by Tsai-Chü could be more or less obliterated by a very important background of oblique rays, I placed another counter tray directly below the absorbent and measured the fivefold coincidences in order to make sure that the radiation really comes from the lead. The results were also negative.

The first curve of Fig. 1 is the same one which we have previously published. It was obtained with two crossed trays of 12 thin glass counters each with fourfold coincidences. The second curve was obtained with two trays of 10 counters instead of 12 (this explains the difference of ordinates). The measurements were carefully checked, and the precision of each point is 1 percent. The 8 percent ratio of fourfold to fivefold coincidences shows that the radiation emerging from the lead is responsible for only 27 percent of the observed counting rate. This explains the small amplitude of the first, well-known maximum.

[1] Tsai-Chü, Phys. Rev. **83**, 867 (1951).
[2] W. Bothe and H. Thurin, Phys. Rev. **79**, 544 (1950).
[3] R. Mazé and Tsai-Chü, Compt. rend. **232**, 224 (1951).

The β-Decay of Radium E and the Pseudoscalar Interaction*

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THE selection rules associated with the five forms of β interaction[1] imply that the only type of transition which can reveal the presence of the pseudoscalar (P) interaction is a $0\rightarrow 0$ yes transition. The contribution of the P interaction to all other types of transitions will be two orders of "forbiddenness" smaller than the contribution from the tensor (T) or axial vector (A) interaction which must be present. Examination of the list of radioactive nuclei[2] shows that one of the most promising candidates for a $0\rightarrow 0$ yes transition is RaE, provided that its β spectrum is simple.[3] If we assume, as in the past, that the β spectrum of RaE is simple, then the forbidden shape which is observed[4] can be explained on the assumption that the spin change is 2 units and that the transition does not involve a parity change. The recent successes of the shell model make it desirable to reexamine this theoretical fit since the RaE nucleus, with its 83 protons and 127 neutrons, is ideally suited for shell model predictions. The shell model predicts[2] that the extra proton is $h_{9/2}$, $f_{7/2}$ or $p_{3/2}$ and that the extra neutron is $i_{11/2}$, $g_{9/2}$ or $d_{5/2}$. The shell model prediction is therefore unequivocal that the parity of RaE is odd although the prediction for the spin is not as clearcut (spin 2 or 0 is favored). Since the parity of the final even-even nucleus must be even, the β-ray transition in RaE must involve a parity change, and the previous fit with no parity change must be regarded as an accident.

We have attempted to fit the RaE β-spectrum by assuming a parity change and considering spin changes from 0 to 2; a spin change larger than 2 is excluded by the lifetime. All possible linear combinations of the five interaction forms (S, V, T, A, P) were examined except those excluded by the Fierz condition,[5] namely (SV) and (TA). The forbidden correction factors were calculated using the formulas of Konopinski and Uhlenbeck[6] and the interference formulas of Smith.[7] The finite radius corrections were taken from the paper by Rose and Holmes.[8] No corrections were applied for screening by the atomic electrons; these are said to be small.[9] Since the chief feature of the correction factor needed to explain the spectrum of RaE is the large ratio ρ (about 2.6) of its value at low energies ($W=1.2\ mc^2$) to its value at high energies ($W=3.0$), it is possible to eliminate all but one of the linear combinations (TP) either by inspection or by maximizing the theoretical ρ.

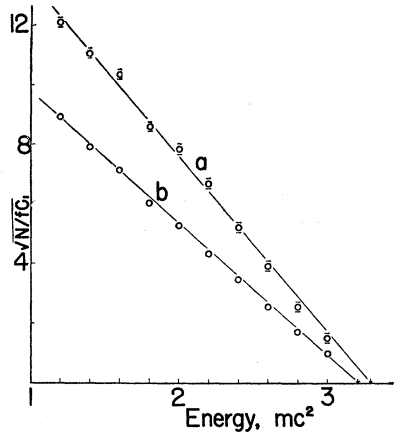

FIG. 1. Kurie plots of the RaE spectrum for (TP) mixture of interactions (a) $W_0=3.29$, $\Gamma=12.8$; (b) $W_0=3.20$, $\Gamma=13.8$.

The details are as follows: $\Delta J=2$, yes gives rise to a unique correction factor on either the T or A theories, which do not interfere; ρ turns out to be 0.7 which is almost a factor 4 too small. $\Delta J=1$, yes allows the following four linear combinations: (ST), (SA), (VT), (VA). For (ST) and (VA), the maximum value of ρ is less than 1.5 and for the other two combinations less than 1.3. These ratios are still too low by a factor of 2. $\Delta J=0$, yes allows the linear combinations (AP) and (TP); the A interaction alone allows the maximum value 1.2 for ρ whereas T alone allows 0.9. The linear combination (AP) does not fare any better; however, for the linear combination (TP) the maximum value of ρ is 3.6, and hence this theory has been subjected to further scrutiny.

The correction factor for the linear combination (TP) corresponding to $\Delta J=0$ yes is, in the notation of Smith:

$$C_{1(T+P)}=(M_0+\tfrac{2}{3}KN_0+\tfrac{1}{3}K^2L_0)+2\Gamma(N_0+\tfrac{1}{3}KL_0)+\Gamma^2L_0, \quad (1)$$

where $\Gamma=-i\lambda_P\int\beta\gamma_5/\lambda_T(\int\beta\sigma\cdot r)^*$ is taken to be real.[10] The large ratios occur where the nearly constant functions M_0, N_0 and L_0 almost cancel, thereby enhancing the importance of accurate values of these functions. Thus, an error in the finite radius corrections of approximately 0.1 percent leads to an error of up to 25 percent in $C_{1(T+P)}$ and explains the large theoretical errors assigned to the points in the Kurie plot of Fig. 1, corresponding to $\Gamma=12.8$ in the correction factor C_1 of Eq. (1). Figure 1 also contains a Kurie plot drawn for an end point of $W_0=3.2\ mc^2$, instead of the accepted $W_0=3.29$, and $\Gamma=13.8$; the required ρ is now 1.9 and the maximum attainable with other mixtures is 1.55 for (ST) or (VA). The theoretical errors in curve (b) are about half those in curve (a); for both curves, the errors are larger than the experimental errors. Reducing the endpoint to $W_0=3.15\ mc^2$ destroys the (TP) fit completely.

Within the errors noted previously, the linear combination of tensor and pseudoscalar interactions corresponding to $\Gamma=13\pm1$, can be regarded as giving a satisfactory fit of the RaE spectrum. Moreover, it is the only linear combination which can explain the forbidden shape of the RaE spectrum if the spectrum is simple and if the parity prediction of the shell model is accepted. Subject to this qualification, our calculation provides the first clearcut evidence for an admixture of the pseudoscalar interaction to explain all β-ray phenomena. It is evident that the $0\rightarrow 0$ yes transition which is indicated for RaE cannot decide whether the S or V interaction must also be added to the (TP) combination.