Letters to the Editor

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On the Decay of Slow Mesons

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IN order to measure accurately the mean life of slow mesons, an experiment was designed to measure their decay curve. The disintegration electron intensity was measured at different time intervals, after the mesons came to rest, through the use of a variable time delay coincidence set.[1]

The counter arrangement used is illustrated in Fig. 1.

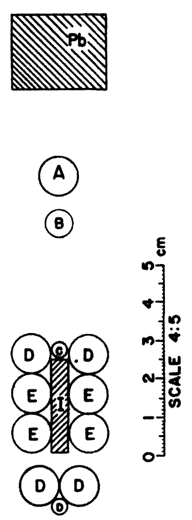

FIG. 1. Counter arrangement.

Counters (A, B, C) are connected to a threefold coincidence system with a coincidence time $T''=2\times10^{-6}$ sec. The counters D are connected to a double channel mixer system[2] and are in anticoincidence with the vertical telescope (A, B, C).[3] The counters E are connected to a double channel mixer system and the coincidences between the pulses from (A, B, C), delayed by a time interval $T\pm T'$, and the pulses from E are measured for different values of T. T' is a constant of the apparatus (coincidence time of the second mixer: $T'=1.2\times10^{-7}$ sec.).

The spurious coincidences are due mainly to showers produced either in the lead block above the counters, which absorbs the soft component, or to knock on showers produced in the iron block I. Both phenomena are eliminated by the anticoincidence counters D. Besides, since the pulses from (A, B, C) are delayed by a time interval $T\pm T'$, relatively to those from counters E, the chance coincidences can be shown to be about 10^{-4} of the observed frequency (the true coincident phenomena such as showers being eliminated by the time delay system).

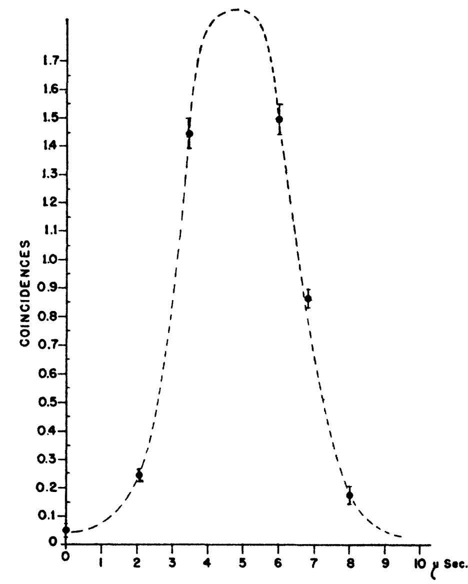

FIG. 2. Coincidences for different time delays.

When $T\lesssim T'$, the observed frequency corresponds both to the decay of mesons which occurred in I and to the scattered mesons, but for $T>T'$ the observed frequency corresponds to the number of mesons disintegrated between $T-T'$ and $T+T'$.

In an experiment such as this one, the results obtained can only be accepted provided that the breakdown time[4] of the counters used is smaller than the coincidence time used; that characteristic can only be obtained through the use of a multivibrator circuit[5] and fast alcohol counters with a discharge started by a Penning effect. In this way, the time lags observed are smaller than the coincidence time used. The obtained efficiency of both apparatus and counters was nearly 100 percent and a complete account of the experimental set used together with the apparatus used to measure small time intervals will be published elsewhere.

The preliminary results obtained are illustrated in Fig. 2 and it is seen that the shape of the curve resembles that of a Gauss distribution around $T_0=5\times10^{-6}$ sec. the curve being symmetrical about the axis $t=5\times10^{-6}$ sec. which was considered as a measure of the "life" of the meson at rest.

The important result to be emphasized here is that the shape of the curve is altogether different from what one would expect from an analogy with the laws of disintegration of radioactive substances. If the time distribution of the decayed mesons would be the same as observed for, say, beta-rays, the shape of the decay curve would be an exponential one.[6] We can therefore conclude that the laws responsible for both beta-ray phenomena are altogether different, and that the law of disintegration of mesons at rest is different from that of beta-rays.

A complete account of the experiment together with new results that are being obtained will be published elsewhere.

It is a pleasure to thank the British Council for the award of a Research Scholarship which has made possible the construction of the apparatus used and to Professors G. Wataghin and G. Occhialini for many helpful discussions.

[1] Prior to the author's measurements, the only coincidence experiments on the detection of delayed electrons were those of Montgomery, Ramsey, Cowie, and Montgomery, with negative results, and the experiments of Rasetti, with a similar geometrical arrangement, but with an altogether different experimental technique.
[2] M. D. de Souza Santos, An. Acad. Bras. Sci. (in press).
[3] G. Occhialini and M. D. de Sousa Santos, *Symposium on Cosmic Rays in Rio de Janeiro (1941)* to be published shortly.
[4] That is, the time interval between the moment in which an ionizing particle passes through the counter and the first electron avalanche reaches the wire.
[5] M. D. de Souza Santos, An. Acad. Bras. Sci. **12**, 183 (1940).
[6] A. Moraes, An. Acad. Bras. Sci. (in the press).

Temperature Diffuse Diffraction Maxima and Crystal Perfection

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THE non-Laue x-ray diffraction maxima called by Raman "modified," and by Zachariasen and others "diffuse" have been observed by many investigators, using a continually growing list of crystals. Existing differences of opinion as to the detailed nature of these effects can be reconciled only on the basis of additional and quantitative observations. For these purposes no observation is more critical than the observation of the angle of deviation of the diffraction maximum. The mere existence of a maximum of a monochromatic line off of coincidence with the Laue spot of the continuum proves nothing. Measurement of the intensity or breadth of the line maximum may assist in classifying the maximum as something other than a Laue or Bragg reflection, though the test is rarely decisive because the theory of the width and intensity of the latter in an imperfect crystal specimen is impossibly complex, and because the maximum is often a mixture of ordinary and temperature diffuse effects. On the other hand, an angle of deviation varying with the angle of incidence is rather decisively indicative of a non-Laue maximum. Demonstration of a deviation which is constant with angle of incidence removes a crystal from consideration in any discussion of temperature diffuse reflection, since it indicates a structure so imperfect that the diffuse reflection, if any, is swamped by the ordinary reflection from misaligned blocks.

A study of six crystalline substances has been conducted with a photographic spectrograph in an attempt to determine the variation of the angle of deviation of Mo $K\alpha$ with angle of incidence. More than 200 exposures were made with the crystal faces inclined to a well-collimated incident beam at angles near the Bragg angle. The results are given in Table I. The order in which the crystals are listed is the order of increasing structural perfection.[1] Apparently neither very perfect nor very imperfect crystals are favorable to studies of the angular shift of the reflected maximum, though the reasons differ in the two cases. With imperfect crystals the situation is as stated in the first paragraph; with a crystal as perfect as the quartz sample the reflection had an observable intensity only at or extremely near the Bragg angle of incidence and no systematic trend could be established even though five-hour exposures were used in an attempt to extend the range of the observations. With the crystals of intermediate perfection there is a qualitative confirmation of theory as shown in columns C and D but a satisfactory quantitative agreement occurs only in the case of barite. The tendency of the observed shift to exceed the theoretical, observed with calcite, has been noted before.[2] One might be inclined to regard it as an instrumental effect except that it does not appear with all crystals.

TABLE I. Variation of angle of deviation of Mo $K\alpha$. A = reflecting planes used. B = range of angles of incidence over which line reflections (Mo $K\alpha_1$ or α_2) were observed. $C = \Delta$ deviation angle/Δ incidence angle observed. $D = \Delta$ deviation angle/Δ incidence angle, theoretical.* E = character of reflected lines.

Crystal	A	B	C	D	E
Iron	100(?)	largest	—	—	broad, unsharp
Zinc blende	110 1	>4°	Appr. zero	—	fairly sharp
Barite	100	54′	$K\alpha_1$ 0.00469 $K\alpha_2$ 0.0203	0.022 .024	sharp
Calcite	100	17′	$K\alpha_1$ 0.26 $K\alpha_2$ 0.218	.0295 .028	sharp
Rochelle salt	?	6′	$K\alpha_1$ 1.95(approx.) $K\alpha_2$ 2.4(approx.)	.0266 .0264	sharp
Quartz	110	negligible	—	—	

* S. Siegel and W. H. Zachariasen, Phys, Rev. **57**, 795 (1940).

[1] R. M. Bozorth and F. E. Haworth, Phys. Rev. **45** 821 (1934). Additional crystals have been arranged from evidence obtained in connection with the research herein described.
[2] P. Kirkpatrick Phys. Rev. **59**, 452 (1941).

The Spectrum of Chlorine I

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MEASUREMENTS on the Zeeman effect in the spectrum of Cl I in the region λλ 3000–9200 have resulted in the identification of several new levels and some lines not listed by Kiess[1] as well as classification of many lines listed in his tables.

The g values and g sums for a few configurations have been determined and show sharing of g sums for the $3s^23p^44p$ and $3s^23p^45p$. The discrepancies in the g sums can be practically completely accounted for on the basis of the overlapping of the $4p(^1D)$ and $5p(^3P)$ parts of these configurations.

A complete report will be published later.

[1] Kiess, Bur. Stand. J. Research **10**, 827 (1933).