$$I(\theta,\varphi)=\sum_{L=0}^{L_{\max}}\sum_{M=-L}^{L} C_L^M Y_L^M(\theta,\varphi),$$

$$L_{\max}=\begin{cases}2S \text{ (integral } S)\\ 2S-1 \text{ (half-odd integral } S),\end{cases}$$

where L can take on only even values. Suppose that the unstable particle travels along the z axis in the laboratory system; and suppose the y axis is chosen along the direction of the reference vector **N**. Then the azimuthal angle φ is just equal to the angle η between **N** and the normal to the decay plane, **n**. The most general form of the probability distribution in η is therefore given by

$$p(\eta)=\int I(\theta,\eta)\sin\theta d\theta$$

$$=\sum_{M=0,2,\ldots}^{L_{\max}}(A_M\cos M\eta+B_M\sin M\eta).$$

A lower limit on S can thus be obtained by determining the largest value of M required to fit the decay data for a series of events. (This is only a lower limit because some of the coefficients in the above expression may vanish; for randomly oriented spins, for example, only A_0 will be nonzero.)

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[1] An excellent summary of theoretical views on the unstable particles, by M. Gell-Mann and A. Pais, will appear in the Proceedings of the International Physics Conference, Glasgow, July 1954.
[2] Fowler, Shutt, Thorndike, and Whittemore, Phys. Rev. 93, 861 (1954).
[3] G. T. Reynolds and S. B. Treiman, Phys. Rev. 94, 207 (1954).
[4] Ballam, Hodson, Martin, Rau, Reynolds, and Treiman, following Letter [Phys. Rev. 97, 245 (1954)].
[5] L. Wolfenstein, Phys. Rev. 75, 1664 (1949).

Orientation of Planes in Double V^0 Decay Events*

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In a set of 30 000 photographs taken of a Wilson cloud chamber operated in a magnetic field,[1] seven events have been found in which a pair of V^0 particles appear to come from a common origin.[2] These have been analyzed for possible angular correlations between the decay planes, as discussed in the preceding letter.[3]

The illuminated region of the chamber has average dimensions 16 in.×16 in. ×5 in. A stereo camera with lens separation of 17° takes two photographs of each event. The spatial geometry of each event is reconstructed by projecting the two views onto a screen through an optical system identical with that used to photograph the chamber. The space coordinates of a particular point on a track are determined by moving the projector parallel to the optic axis of the lenses, until the point appears stationary on the screen when the two views are projected in rapid succession. The screen-projector distance measures the z coordinate of the point (a correction is made for chamber expansion); and the location on the screen determines the x and y coordinates. This procedure is repeated for many points along each relevant track, so that a spatial reconstruction of the entire event is obtained. An alternate procedure, which determines directly the orientation of the decay planes, consists in tilting the screen until the images of both decay tracks of a particular V^0 event appear stationary when the two stereo views are projected in rapid succession. This procedure is less accurate than the one described above, but in every case the two methods agreed to within a few degrees.

In each event a search was made for all possible origins of the two V^0 particles. We assume that the V^0 particles undergo two-body decay, so that the origin for a given V^0 must lie in its decay plane and the line connecting the origin with the decay point must pass

Table I. Summary of geometrical data for ten V^0-particle pairs. δ is angle of noncoplanarity with assumed origin. θ_1 is angle between lines of flight of V_a^0 and V_b^0. θ_2 is angle between decay planes of V_a^0 and V_b^0. η is angle between decay plane and plane containing lines of flight of V_a^0 and V_b^0. The last column gives the identification.

Event	V^0	δ	θ_1	θ_2	η	Ident.
26–5946	a	1.4°	36.6°	76.6°	14.8± 4°	···
	b	2.1			88.5± 5	···
56–240	a	2.7	31.8	78.5	16.0±11	···
	b	3.7			62.6±10	···
69–210	a	0.6	43.8	45.2	29.0± 3	···
	b	2.1			63.7± 3	θ^0
73–29	a	0.5	20.6	62.2	25.3± 5	Λ^0
	b	0.8			85.8± 5	θ^0
95–622	a	1.3	41.4	72.5	39.8± 3	θ^0
	b	0.4			78.3± 4	θ^0
126B–30034	a	0.7	3.1	44.8	4.4± 3	···
	b	0.2			40.0± 3	···
146B–40761	a	0.1	14.5	88.0	17.0± 3	···
	b	0.4			72.4± 4	···
Brookhaven	a				27 ±10	Λ^0
	b				70 ± 5	θ^0
Brookhaven	a				18 ± 7	Λ^0
	b				60 ± 6	θ^0
Thompson *et al.*	a				10.6	θ^0
	b				26.5	Λ^0

between the two decay tracks. Evidently, we can only locate origins which give rise to more than one charged particle passing into the illuminated region of the chamber. In each of the seven V^0 pair events, however, there was one, and only one, such origin for each decay plane and this origin was in fact common to both planes. This suggests that in each event the two V^0 particles indeed came from a common origin, which we had correctly located.

The results of the analysis are summarized in Table I. The angle of "noncoplanarity," δ, is the angle between the line of flight of the V^0 particle and the decay plane. Within the experimental errors, the assumed origin in each case lies in the decay plane. It is the angle η between the decay plane and the plane containing the lines of flight of the two V^0 particles that is of particular interest. By convention, $\eta_a<\eta_b$. Normals are chosen so that $\eta\leq 90°$. The errors in η arise mainly from the uncertainties in the precise location of the origin. Table I also includes two V^0-pair events obtained by the Brookhaven group[4] and one event obtained by Thompson *et al.*[5]

In Fig. 1 each event is represented by a point in the $\eta_a-\eta_b$ plane. Since $\eta_a<\eta_b$, the points are constrained to lie to the right of the 45° line. As discussed in the preceding letter, if both of the V^0 particles involved in each event have spin less than one, the points should be uniformly distributed over the plane to the right of the 45° line. Although only 10 events are represented in the figure and the statistics are correspondingly poor, there appears to be a significant clustering of points in the region of small η_a, large η_b. We can think of no bias in our experimental procedure which would tend to distort the true distribution.

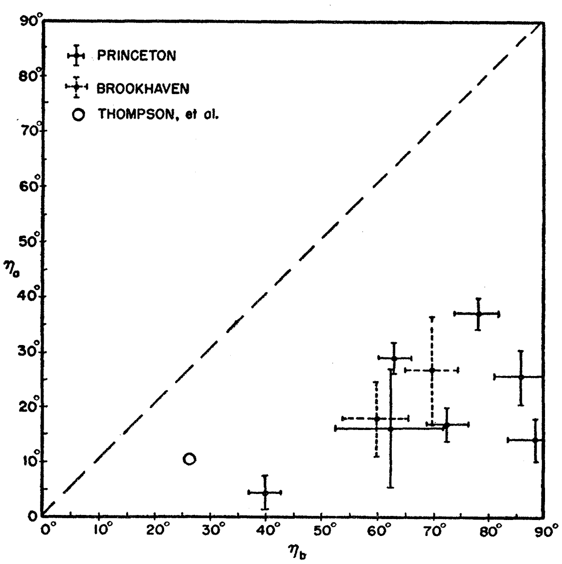

FIG. 1. Distribution of events in the $\eta_a-\eta_b$ plane for ten V^0-particle pairs; η is the angle between the decay plane of an individual V^0 particle and the plane containing the lines of flight of the two V^0 particles of the pair. The subscripts a and b distinguish the two V^0 particles and have been chosen in such a way that $\eta_a<\eta_b$.

Insofar as this apparently nonuniform distribution is accepted as statistically significant, we can conclude that at least one type of V^0 particle involved in our sample has spin greater than one-half.

Unfortunately, identification of the V^0 particles could be made in only a few cases—and then only on the basis of angles and ionizations, assuming that we are dealing only with a mixture of $\Lambda^0\rightarrow p+\pi^-+37$ Mev and $\theta^0\rightarrow\pi^++\pi^-+214$ Mev. Thus, the statement that a certain particle is a θ^0 means that on the basis of angles and ionizations the event is consistent with θ^0 and inconsistent with Λ^0. Event 95–622, which appears to involve a pair of θ^0-particles, has been described elsewhere.[6]

There is of course no way to determine in our events whether the two V^0 particles are produced in a single elementary act or in two separate interactions. The very existence of correlation effects, however, would seem to favor the first possibility.

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[1] Hodson, Ballam, Arnold, Harris, Rau, Reynolds, and Treiman, Phys. Rev. **96**, 1089 (1954).

[2] The same set of photographs gave about 250 single V^0 events, 60 V^+ events, and several additional V^0 pairs; the latter were not accepted for the present analysis, however, because it was not possible to determine reliably whether the two V^0 particles came from a common origin.

[3] Treiman, Reynolds, and Hodson, preceding Letter [Phys. Rev. **97**, 244 (1954)].

[4] Fowler, Shutt, Thorndike, and Whittemore, Phys. Rev. **93**, 961 (1954).

[5] Thompson, Burwell, Huggett, and Karzmark, Phys. Rev. **95**, 1576 (1954).

[6] D. R. Harris and A. L. Hodson, Phys. **95**, 661 (1954).

Spectrometry of Recoils from Neutrino Emission in Argon-37

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As has been recognized for some time, argon-37 offers unusual advantages for neutrino recoil experimentation in that it is monatomic and gaseous and captures orbital electrons without gamma emission, so that neutrino emission should be the predominant mechanism which could give recoil. The recoils have been observed by Rodeback and Allen[1] through the use of coincidence time-of-flight methods and very recently by Kofoed-Hansen[2] in a parallel-plate, crossed-field spectrometer. The energy of the radioactive transition is known to be 816 kev,[3] from which one would predict a recoil energy of 9.66 ev for the Cl^{37} atoms; the latter are known to be multiply-charged because of the emission of Auger electrons.[4]

We have found that it is possible to examine these low-energy recoils in detail and under high resolution