each telescope, and 9% of that number were measured to be accidental counts and counts resulting from mesons stopping in the target walls and in the precession solenoid. Correcting only for this small background, we obtain for the asymmetry in each telescope

$$Ka = 0.274 \pm 0.016 \quad \text{for telescope 1}$$
$$= 0.276 \pm 0.016 \quad \text{for telescope 2,}$$

where the uncertainties indicated are statistical only.

The factors K for the polarization and the counting arrangement in this experiment are:

$$K = 0.850 \pm 0.024 \quad \text{for telescope 1}$$
$$= 0.844 \pm 0.024 \quad \text{for telescope 2.}$$

To compute K, it was necessary to know the fraction of electrons which has insufficient energy to be counted in the detecting telescopes. The energy and angular dependence of the muon decay electrons was assumed to be the one predicted by the two-component neutrino theory.[2] The probability of counting an electron as a function of energy and material traversed was obtained with Wilson's range formula,[3] and the measured distribution of muons stopping in the target. The errors indicated in K are due primarily to a 2% uncertainty in the polarization resulting from the uncertainty in the muon energy interval defined by the bromoform target, and to a 2% uncertainty which is contributed by the energy dependence of the electron counting efficiency; and also to an additional 1% uncertainty due to the fact that the current required to obtain the $\pm 90°$ precession is known to 10%.

Combining the data from the two telescopes, the asymmetry parameter is found to be

$$|a| \geqslant 0.325 \pm 0.015,$$

where the inequality arises from the possible depolarization of the muons stopping in bromoform. These depolarization effects are unknown; but, of a large number of materials tested, bromoform has been shown[4] to cause the least depolarization.

With the assumption of two-component neutrino theory, and with the coupling scheme $(e\nu)(\nu\mu)$,

$$3|a| = |\xi| = \left|\frac{|g_S|^2 - 4|g_V|^2}{|g_S|^2 + 4|g_V|^2}\right|;$$

then we have shown that

$$|\xi| \geqslant 0.97 \pm 0.05.$$

Measurements of the μ spin direction[5] indicate that ξ is negative, so that we have, in terms of the coupling constants,

$$|g_S|^2/|g_V|^2 \leqslant 0.05 \pm 0.09.$$

---

*Research supported in part by the Office of Naval Research and the U. S. Atomic Energy Commission.

†On leave. Present address: CERN, Geneva, Switzerland.

[1]Garwin, Lederman, and Weinrich, Phys. Rev. 105, 1415 (1957).

[2]T. D. Lee and C. N. Yang, Phys. Rev. 105, 675 (1957).

[3]R. R. Wilson, Phys. Rev. 84, 100 (1951).

[4]Proceedings of the Seventh Annual Rochester Conference on High-Energy Physics (Interscience Publishers, New York, 1957).

[5]Culligan, Frank, Holt, Kluyver, and Massam, Nature 180, 751 (1957).

POSSIBLE DETERMINATION OF $K\Lambda$ RELATIVE PARITY*

Luciano Fonda and J. E. Russell
Physics Department,
Indiana University,
Bloomington, Indiana
(Received December 16, 1958)

Okun' and Pomeranchuk[1] have suggested that a study of the absorption of bound K^- mesons in hydrogen according to the infrequently occurring reactions

$$K^- + p \to \Lambda^0 + \pi^0 + \pi^0, \tag{1}$$
$$K^- + p \to \Lambda^0 + \pi^+ + \pi^-, \tag{2}$$

might yield information regarding $P_{K\Lambda}$, the $K\Lambda$ relative parity. The K^- meson was assumed to be initially in an S state. For reaction (2) it was found that an angular correlation between the directions of the relative momentum $\vec{p}_\pi$ of the two pions and the momentum $\vec{p}_\Lambda$ of the Λ^0 hyperon would indicate $P_{K\Lambda} = -1$. Also, $P_{K\Lambda} = -1$ would result in the Λ^0 from reaction (2) being polarized with respect to the reaction plane. In addition, the probability for reaction (1) relative to that for reaction (2) depends on $P_{K\Lambda}$. However, as Okun' and Pomeranchuk have emphasized, the interpretation of experimental data would be ambiguous due to our present lack of knowledge regarding the P wave interaction in the KN system and the time dependence of the relative populations of levels in newly formed K^- mesonic atoms.

The purpose of this note is to suggest that much the same results obtain for the absorption in flight of K^- mesons with laboratory energies below approximately 30 Mev. Moreover, other effects will be present which also depend on $P_{K\Lambda}$. If $P_{K\Lambda} = -1$ the directions of both $\vec{p}_\pi$ and $\vec{p}_\Lambda$ in the center-of-mass (c.m.) system will be correlated in reaction (2) with the direction of $\vec{p}_K$, the c.m. momentum of the incident K^- meson; in reaction (1) only $\vec{p}_\Lambda$ and $\vec{p}_K$ will have an angular correlation. For $P_{K\Lambda} = -1$ the Λ^0 will be polarized in both (1) and (2). Furthermore, $P_{K\Lambda}$ determines the energy dependence of the cross sections.

The physical reasons for these assertions are as follows. In the c.m. system the initial relative motion of the K^- meson and proton is described by a superposition of partial waves, each of which has a definite total angular momentum and parity which are both conserved in the reactions (1) and (2). It is possible to transform the c.m. coordinates and momenta describing the products of these reactions in such a way that the total angular momentum operator is given by the sum of two angular momentum operators which are related to the motion of the Λ^0 and the relative motion of the two pions, respectively. The final state which corresponds to a particular incident partial wave may then be represented asymptotically by an infinite series of products of two wave functions, each product describing a suitable combination of spin and orbital motion of the Λ^0 and the two pions which is compatible with the conservation laws and possible identity of the pions. For these final states it will be assumed that only the lowest possible combinations of orbital angular momenta are significant for the range of K^- energies being considered. This assumption is based on the fact that the energies released in (1) and (2) are low, being 47 and 38 Mev, respectively, for capture at rest. The wave functions for higher orbital angular momenta will have much smaller amplitudes in the region of interaction, which is assumed to be less than 10^{-13} cm. These considerations are similar to those employed by Dalitz[2] in his analysis of τ decay. The spins of the K^- and Λ^0 are assumed to be 0 and $\frac{1}{2}$, respectively. If $P_{K\Lambda} = +1$ an incident S wave is transformed into two final S waves. The effect of incident P waves will be small. The angular distributions will be isotropic, and angular momentum conservation will require the Λ^0 to be unpolarized. However, if $P_{K\Lambda} = -1$ an incident S wave will emerge as suitable combination of S and P waves, and, in the same order of approximation, an incident $P_{1/2}$ wave will emerge as a combination of two S waves. The angular distributions will not be isotropic, and, due to interference effects, the Λ^0 will be polarized. There will be a different energy dependence of the cross sections because the amplitudes of the P waves in the interaction region increase as the K^- energy becomes larger.

These qualitative considerations will now be put in a more definite form. The amplitudes for the transitions are expanded in powers of $(\vec{p}_K R)$, $(\vec{p}_\pi R)$, and $(\vec{p}_\Lambda R)$ where R is a distance determined by the range of the interaction. For the energies being considered it will suffice to retain only the terms of lowest order. It will be assumed that reactions (1) and (2) conserve isotopic spin. The amplitudes A_1 and A_2 for reactions (1) and (2), respectively, are scalar (pseudoscalar) if $P_{K\Lambda} = +1$ ($P_{K\Lambda} = -1$). In the following $\vec{\sigma}$ is the vector of the Pauli matrices, $d\rho_F$ denotes the density of final states, $\vec{\zeta}$ is a unit pseudovector in the direction of polarization, v is the velocity of the incident K^- meson, and Q_1 and Q_2 are the energies released in (1) and (2), respectively, for capture at rest. The total cross sections σ_1 and σ_2 for (1) and (2), respectively, obtained by integrating the differential cross sections $d\sigma_1$ and $d\sigma_2$ over the available phase space, are also given below. Also, T_i is given by

$$T_i = Q_i + p_K^2/(2\mu), \quad i = 1, 2$$

where μ is the reduced mass of the Kp system.

For $P_{K\Lambda} = +1$ we have

$$A_1 = -a'/\sqrt{2}, \; A_2 = a',$$

$$d\sigma_1 = (1/4v)\,|a'|^2\, d\rho_F,$$

$$d\sigma_2 = (1/2v)\,|a'|^2\, d\rho_F,$$

$$\sigma_1 \sim (1/2v)\, T_1^2\, |a'|^2,$$

$$\sigma_2 \sim (1/v)\, T_2^2\, |a'|^2.$$

For $P_{K\Lambda} = -1$ we have

$$A_1 = -(a\vec{\sigma}\cdot\vec{p}_K + b\vec{\sigma}\cdot\vec{p}_\Lambda)/\sqrt{2},$$

$$A_2 = a\vec{\sigma}\cdot\vec{p}_K + b\vec{\sigma}\cdot\vec{p}_\Lambda + c\vec{\sigma}\cdot\vec{p}_\pi,$$

$$d\sigma_1 = (1/4v)\{|a|^2 p_K^2 + |b|^2 p_\Lambda^2 + 2\,\mathrm{Re}\,(a^* b)\vec{p}_K\cdot\vec{p}_\Lambda + 2\,\mathrm{Im}\,(a^* b)(\vec{p}_K\times\vec{p}_\Lambda)\cdot\vec{\zeta}\}d\rho_F,$$

$$d\sigma_2 = (1/2v)\{|a|^2 p_K^2 + |b|^2 p_\Lambda^2 + |c|^2 p_\pi^2 + 2\,\mathrm{Re}\,[a^* b\,\vec{p}_K\cdot\vec{p}_\Lambda + b^* c\,\vec{p}_\Lambda\cdot\vec{p}_\pi + c^* a\,\vec{p}_\pi\cdot\vec{p}_K] + 2\,\mathrm{Im}\,[a^* b\,(\vec{p}_K\times\vec{p}_\Lambda) + b^* c(\vec{p}_\Lambda\times\vec{p}_\pi) + c^* a\,(\vec{p}_\pi\times\vec{p}_K)]\cdot\vec{\zeta}\}d\rho_F,$$

$$\sigma_1 \sim (1/2v)\,T_1^2\{0.34\,|b|^2(2\mu Q_1) + [\,|a|^2 + 0.34\,|b|^2]p_K^2\},$$

$$\sigma_2 \sim (1/v)\,T_2^2\{[0.34\,|b|^2 + 0.43\,|c|^2](2\mu Q_2) + [\,|a|^2 + 0.34\,|b|^2 + 0.43\,|c|^2]p_K^2\}.$$

The interpretation of data on absorption of K^- mesons in flight at low energies should be less ambiguous than that for absorption at rest. The greatest difficulty would appear to be the small cross sections for reactions (1) and (2).

---

*Supported by the National Science Foundation.

[1]L. B. Okun' and I. Ia. Pomeranchuk, J. Exptl. Theoret. Phys. (U.S.S.R.) 34, 997 (1958) [translation: Soviet Phys. JETP 34, 688 (1958)].

[2]See, for example, R. H. Dalitz, Reports on Progress in Physics (the Physical Society, London, 1957), Vol. 20, p. 163, and references contained therein.

POSSIBLE EXPLANATION OF HYPERFRAGMENT SUPPRESSION IN K^--d REACTIONS*

T. B. Day
University of Maryland,
College Park, Maryland

and

G. A. Snow
University of Maryland,
College Park, Maryland
and United States Naval Research Laboratory,
Washington, D. C.

(Received December 15, 1958)

One of the reactions that can occur when a K^- meson is captured from an atomic orbit about a deuteron is

$$K^- + d \rightarrow \Sigma^- + n + \pi^+. \qquad (1)$$

Pais and Treiman[1] have investigated the probability of formation of a bound state of the (Σ^-, n) system, if such a system exists. They concluded that if the (Σ^-, n) binding energy was of the order of a few tenths of a Mev or larger, the probability of bound-state formation via reaction (1) is ~40%, except if the K^- meson were pseudoscalar, and the singlet state of the (Σ^-, n) system is the only bound system.

A re-examination of this problem indicates that there is one important process that was not included in their work; that is, the absorption of the K^- meson from the $2P$ atomic orbit via an s-wave capture process of the type

$$K^- + p \rightarrow \Sigma^- + \pi^+. \qquad (2)$$

The rate of this (K^-, p) s-wave capture from the $2P$ orbit is nonvanishing since the deuteron has a finite size and the rate is proportional to the square of the $2P$ orbital wave function evaluated at the position of the proton in the deuteron. Furthermore, a crude estimate of the total absorption rate from the $2P$ orbit by s-wave capture $\Gamma(P, s)$, indicates that it is ~10 times larger than either the $2P \rightarrow 1S$ radiative rate $\Gamma(P, \gamma)$ or the $2P$ absorption rate via p-wave capture. It is the purpose of this letter to show that the probability of the formation of the (Σ^-, n) bound state via the s-wave capture process from the $2P$ orbit is one order of magnitude smaller than for the processes considered in PT.

In the following discussion, the notation and approximations of PT are used. These approximations consist in the use of the impulse approximation and two-parameter Hulthén wave functions for the bound states.

Assuming that the K^- meson is pseudoscalar with respect to the (Σ^-, n) system, and that the (Σ^-, n) bound state has spin 1, then, analogous to Eq. (8) of PT, the bound-state transition rate via the s-wave (K^-, p) interaction can be written

$$R_B = \tfrac{2}{3}\pi\,|a|^2 \sum_{m_l} \int \left| y^{m_l} \right|^2 \frac{d\vec{P}_\pi}{(2\pi)^3\,dE}, \qquad (3)$$

where

$$y^{m_l} = \int d\vec{r}\; v_B^*(\vec{r}) e^{-i\vec{k}_0\cdot\vec{r}} u(\vec{r})\, \psi_{2P}^{m_l}(\vec{r}/2). \qquad (4)$$

ψ_{2P} is the K^- wave function in the $2P$ orbit and the other symbols are explained in PT. Since only small values of the argument of ψ_{2P} are important, $\psi_{2P}(\vec{r}/2)$ can be replaced by $\frac{1}{2}\vec{r}\cdot\nabla\psi_{2P}(0)$, and the evaluation of R_B is straightforward in