of $\Gamma_{e\pm}$ from the $C^{12}(e,e')$ measurement. It would seem that (a) is the most likely possibility. This would allow $\Gamma_{3.2\gamma}$, which is probably the dominant path to the ground state, to be in agreement with the single-particle estimate, and it would also explain why attempts to detect the 3.2-Mev gamma ray have not yet met with success.

Full details of these experiments will be published later. The author is greatly indebted to the staff of the Oak Ridge National Laboratory for their hospitality and to Dr. Paul H. Stelson for his invaluable assistance.

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[*] Permanent address: Brookhaven National Laboratory. This research was carried out at Oak Ridge National Laboratory while the author was a visitor during the summer of 1959.

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POSSIBILITY OF STUDYING THE Λ-HYPERON–NUCLEON FORCE BY LOW-ENERGY SCATTERING

C. G. Gardner and T. A. Welton
Oak Ridge National Laboratory, Oak Ridge, Tennessee

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Currently our ideas concerning the Λ-hyperon–nucleon force derive primarily from (a) meson-theoretic static models, together with restrictions imposed by isotopic spin conservation,[1-3] and (b) analysis of the binding energies and decay mode branching ratios of hyperfragments.[2-6] Such considerations have led to the following characterization of the Λ-hyperon–nucleon force: (1) it is of shorter range than the nucleon-nucleon force, most likely having a characterisitc range $a \approx \hbar/2m_\pi c$, corresponding to a 2-pion exchange process; (2) it is "weaker" than the nucleon-nucleon force, being of insufficient strength to bind a Λ hyperon to a single nucleon; (3) it is spin dependent; and (4) the singlet force is somewhat stronger than the triplet force.[7]

We wish to note that the polarization which arises in the production of Λ hyperons may be used in a simple way to explore the spin dependence of the s-state Λ-hyperon–nucleon force. Let us for the moment assume that there is available a beam of low-energy ($\lesssim$25-30 Mev, center of mass)[8] Λ hyperons which are polarized in some direction (specified by the unit vector $\vec{n}$) by an amount $\langle\vec{\sigma}_\Lambda \cdot \vec{n}\rangle = P_\Lambda$, and which are allowed to scatter from unpolarized (free) protons; let us further suppose that the scattering is in fact observed to be isotropic (in the center-of-mass system) so that we are observing the effects of the s-state Λ-hyperon–nucleon force. It is straightforward to show that the polarization $P_{\Lambda(\text{final})}$ of the Λ hyperon after the scattering is related to its initial polarization in the following way:

$$D = \frac{P_{\Lambda(\text{final})}}{P_{\Lambda(\text{initial})}} = \frac{2[\sin^2\delta_t + \sin\delta_t \sin\delta_s \cos(\delta_t - \delta_s)]}{3\sin^2\delta_t + \sin^2\delta_s}. \tag{1}$$

δ_t and δ_s are, respectively, the triplet and singlet state scattering phase shifts. The direction of polarization is, of course, unchanged if the scattering is s-state scattering. One notes that for a spin-independent force ($\delta_t = \delta_s$), $D = 1$, i.e., the polarization is unchanged. If $\delta_t \gg \delta_s$, $D \simeq \frac{2}{3}$; conversely, if $\delta_s \gg \delta_t$, $D \simeq 0$, i.e., the Λ hyperon is strongly depolarized. Hence, one can say that any reduction in polarization of the Λ hyperon is evidence for spin dependence of Λ-hyperon–nucleon force; a reduction by a factor greater than $\frac{2}{3}$ is evidence that the singlet force is "stronger" than the triplet force.

In order to estimate the magnitude of D as a function of the relative strengths of the singlet and triplet forces, we suppose the Λ-hyperon–nucleon s-state potential to be of the following form:

$$F_{N\text{-}\Lambda}(r) = -\frac{692.3\ \text{Mev-fermi}^2}{b^2} \times \exp[-3.541(r/b)](s_t P_t + s_s P_s), \quad (2)$$

where b is the intrinsic range of the well and s_t and s_s are, respectively, the triplet and singlet well-depth parameters[9]; P_s and P_t are, respectively, singlet and triplet projection operators. We assume that the intrinsic range of both wells is the same and corresponds to a 2-pion characteristic range, for which $b = 1.484$ (measured in fermis). For definiteness in computations, we have assumed that $s_s = 0.8$ (an "average" well-depth parameter $\simeq 0.75$ has been suggested on the basis of a variational study of hypertritium)[4]: we then compute phase shifts for $0 \leq (V_{\text{singlet}}/V_{\text{triplet}}) = (s_s/s_t) \lesssim 5$.

Although an exact analytical expression for the s-state phase shift due to an exponential well can be calculated, we have, for numerical ease, employed the effective-range approximation,[8]

$$k\cot\delta = -\alpha + \tfrac{1}{2}r_0 k^2, \quad (3)$$

which should be satisfactory for energies at which it is safe to neglect p-state scattering. Figure 1 presents the Λ-hyperon depolarization factor D as a function of (s_s/s_t), as given by these computations.

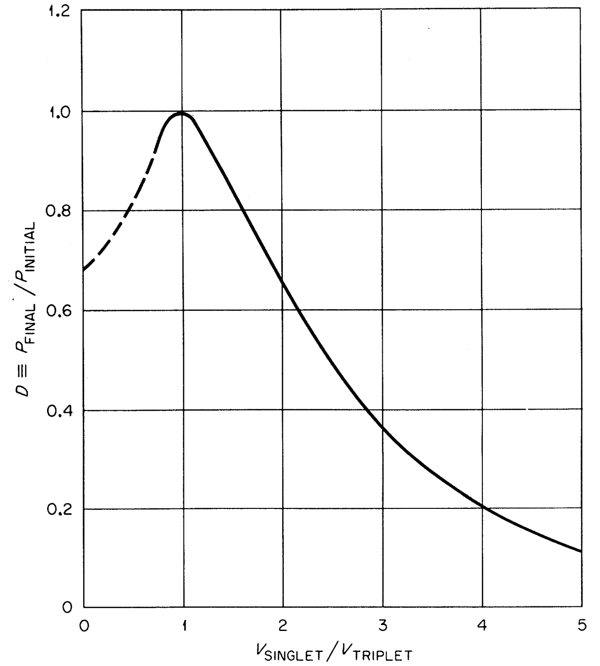

FIG. 1. Depolarization of scattered Λ hyperon of 20-Mev incident kinetic energy (lab) for an assumed singlet well depth parameter $s_{\text{singlet}} = 0.8$.

While no great significance should be attached to the precise numerical values obtained above, it seems safe to conclude that if the singlet well is two to three times as deep as the triplet well, the Λ-hyperon depolarization factor D will be significantly smaller than the ambiguous values $\frac{2}{3} \leq D \leq 1$.

Finally, we note that the above considerations are not necessarily entirely academic. The basic ingredients are: (1) a source of polarized Λ hyperons whose (laboratory) kinetic energy is less than, say, 60 Mev; (2) unpolarized (free) proton scattering centers; and (3) a polarization analyzer. These requirements are all met by associated Λ-hyperon production in a hydrogen bubble chamber. For example, the familiar reaction

$$\pi^- + p \to K^0 + \Lambda^0 \quad (4)$$

is known to be strongly polarizing at the production energies used heretofore.[10,11] Further, as is well known, the parity-nonconserving features of the Λ-hyperon decay serve as an analyzer of the Λ-hyperon polarization.[10-13] (For our purposes, a measurement of αP, where α is the customary asymmetry parameter in Λ-hyperon decay,[12] is as useful as a measurement of P_Λ itself, since we require only the ratio $P_{\text{final}}/P_{\text{initial}}$.) The hydrogen in the bubble chamber provides the required scattering centers. (A few elastic scattering events of the type $\Lambda + p \to \Lambda + p$ in a hydrogen bubble chamber have been observed.[14]) Hence, one needs at an appropriate production energy sufficient analyzable events of the type

$$\pi^- + p \to K^0 + \Lambda^0, \quad \Lambda^0 \to p + \pi^-, \quad (5)$$

to establish αP as a function of center-of-mass angle of production; one then needs sufficient completely analyzable events of the type

$$\pi^- + p \to K^0 + \Lambda^0, \quad \Lambda^0 + p \to \Lambda^0 + p, \quad \Lambda^0 \to p + \pi^-, \quad (6)$$

to establish αP_Λ after the elastic scattering. As a source of low-energy polarized Λ hyperons, reaction (4) has, for our purposes, obvious kinematical disadvantages; the center-of-mass motion brought about by the fairly high reaction threshold requires that one go to higher production energies in order that the low-energy component in the cone of Λ-hyperon production contain Λ hyperons of sufficiently low energy to be useful. An incident poin momentum of 2 Bev/c

would provide Λ hyperons of energies down to approximately 30 Mev (laboratory), an energy not too high to be useful. Unfortunately, at this incident momentum, a large number of alternative channels are competing.

Although not yet known (to us) to be polarizing, the in-flight reaction

$$K^- + p \to \pi^0 + \Lambda^0 \tag{7}$$

is quite favorable kinematically, providing, for example, Λ hyperons of (laboratory) kinetic energy of from 9 Mev to 72 Mev over the cone of production (in addition, of course, there is a much higher energy component), at an incident K-meson momentum of 2 Bev/c. Should reaction (7) prove polarizing at moderate production energies, it would be more useful as a source of low-energy Λ hyperons for scattering than is reaction (4). A third alternative which is kinematically favorable (and which may well prove polarizing)[15] is associated photoproduction of Λ hyperons:

$$\gamma + p \to K^0 + \Lambda^0. \tag{8}$$

If reactions (7) and (8) turn out to be polarizing (information important within itself), then the feasibility of a useful study of Λ-hyperon–nucleon scattering as outlined above would be considerably enhanced.

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POSSIBLE EVIDENCE FOR A NEGATIVE HEAVY MESON[*]

T. Yamanouchi and M. F. Kaplon
Department of Physics and Astronomy, University of Rochester, Rochester, New York

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Following the report of the High-Energy Conference at Kiev in which evidence was presented for the existence of a heavy positive meson decaying into a π^+ and a K^0,[1] we decided to see if there was any additional evidence relating to the existence of such particles. If such a particle should exist it presumably has strangeness +2 and it would seem reasonable that its antiparticle with strangeness -2 might exist. To this end we re-surveyed the scanning of an emulsion stack exposed to the 300-Mev/c Berkeley K^- beam[2] for stars which might indicate anomalously high-energy release.

We found two events of interest. The first and the one which gives evidence for the possible existence of a new negative meson is shown in Fig. 1 in a schematic sketch. It has a total of 8 prongs, one of which labelled P is the primary particle initiating the event; it lies in the beam direction and the grain density measurements at 0.5 mm and 8.5 mm from the star yield the values 2.89 ± 0.12 and 2.58 ± 0.11 times the minimum, respectively, indicating that the particle is indeed moving in the direction of the star. Of the prongs emitted two are of particular interest. Prong No. 7 is a "picture book" Σ^+ hyperon decaying at rest by the protonic mode; it has an energy at emission of 23.2 Mev and the decay proton an energy of 18.8 Mev. Prong No. 6 is the one which, in conjunction with No. 7, gives the event its pe-