345 (1957).

[15]This general, relativistic decay rate (partial width) is to be contrasted with that used in reference 8: No attempt is made here to include the effect of the symmetry-breaking interaction by including another adjustable parameter. See E. C. G. Sudarshan, A. J. Macfarlane, and C. Dullemond, Phys. Rev. Letters 10, 423 (1963), for the method of handling partial widths in the presence of symmetry-breaking interactions.

[16]R. Cutkosky (to be published). The baryon-meson product wave function is $\cos\theta$ times the normalized symmetric combination plus $\sin\theta$ times the normalized antisymmetric combination. For example,

$$Y_1^{*+} = (\sin\theta/\sqrt{6})[p\bar{K}^0 + \Xi^0K^+ + \sqrt{2}(\Sigma^+\pi^0 - \Sigma^0\pi^+)] + (\sqrt{3}/10)\cos\theta[-p\bar{K}^0 + \Xi^0K^+ + (\sqrt{2}/3)\Lambda\pi^+ + (\sqrt{2}/3)\Sigma^+\pi^0].$$

[17]To second order in the symmetry-breaking interaction, the mass formula has four parameters for $N=8$ so that no predictions can be made, while for $N=10$ the formula has three parameters and one prediction can be made. See reference 7.

[18]B. Diu, Nuovo Cimento 28, 466 (1963); J. Ginibre, J. Math. Phys. 4, 720 (1963).

[19]To understand how a nearby level from another representation might cause a deviation from an equal-spacing law, consider a dynamical model in which a massive field is responsible for the symmetry-breaking interaction (in analogy with the massless electromagnetic field which is responsible for the isospin symmetry-breaking interaction). It is conceivable that for an isolated supermultiplet this mesonic field could give an equal-spacing law. Moreover in a convergent field theory, one might expect only near-lying levels to be important. Thus, if this mesonic field can connect two different representations (e.g., a field like the π's can connect the Σ and Λ, the $N=1$ and 7 representations) which lie close together, one would expect a deviation from an equal-spacing law in each representation so connected.

[20]It is clear that a dynamical model for the symmetry-breaking interaction as discussed in reference 17 will lead, of course, to significant changes in the predictions for the electromagnetic vertex functions.

[21]Because of the existence of the N^{****} (with $I=3/2$, $J>7/2$) at 1920 MeV, we suspect the existence of an $I=0, Y=2$ resonance and in K^+n and K^0p scattering around 1800-1900 MeV (with $J\geq 7/2$).

MODERATION TIME FOR NUCLEAR CAPTURE OF NEGATIVE PIONS IN LIQUID He^4†

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The purpose of the experiment reported here was twofold: (a) to measure, following analogous studies[1,2] performed in liquid hydrogen, the mean time $\tau_C(2\alpha)$ spent (presumably in bound orbits) by a negative pion in going from a velocity $v_0 \approx 2\alpha c$ to nuclear capture; (b) to obtain an accurate range spectrum of the prong produced in the nuclear caputre of a pion by He^4.

It is clear that the behavior of bound negative pions in liquid He will differ at least in two respects from the "equivalent" situation in liquid H_2. Firstly, the π-He system is an ion, and hence is not expected to penetrate deeply into neighboring He atoms (and undergo Stark effect) like the neutral π-H system in H_2. Secondly, the nuclear capture channels available to the π-He system are quite different; in particular, the channel $\pi^- + p \to \pi^0 + n$ is energetically forbidden in He; on the other hand, 2-nucleon capture, which can occur from atomic p states in the π-He system, is obviously absent in the π-H system.

A beam of slow π^- mesons was brought to rest in a He^4 bubble chamber, $20\times12\times10$ cm^3, operated in a 5-kG magnetic field. A mean number of ~6 stops/picture was obtained. The pictures were scanned for two types of events: (a) π-μ-e decays, with a muon track making an angle of >60° (in at least one projected view) with respect to the parent pion track; (b) pion "stars," yielding either no capture prong or a prong stopping in the chamber. The fiducial volume (~$15\times10\times8$ cm^3) was so chosen that tracks with ranges ≤3.5 cm were detected with an efficiency ≥90%.

As explained in references 1 and 2, the time $\tau_C(2\alpha)$ is given by $\tau_C(2\alpha) = 2n\tau_\pi/N$, where n is the number of π-μ decays into the backward hemi sphere with muon range compatible with $v \leq 2\alpha c$, N is the total number of pion stops, and τ_π is

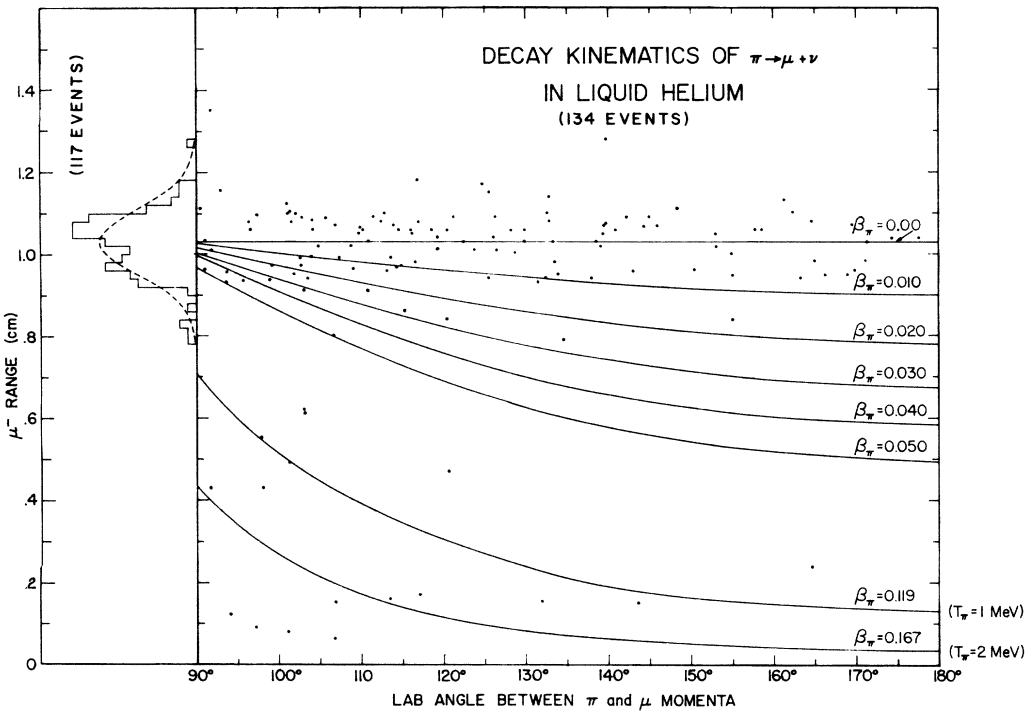

FIG. 1. Kinematics of π^--μ^- decay in flight in liquid He of density (0.141 ± 0.003) g/cm^3. Each dot represents one decay found in a total of $N = 18\,540$ pion stops. The histogram to the left is the range distribution of the 117 events contained between 0.7 and 1.3 cm. Also shown, as a suitably normalized dashed Gaussian curve, is a μ^+ range spectrum based on 295 π^+ decays at rest.

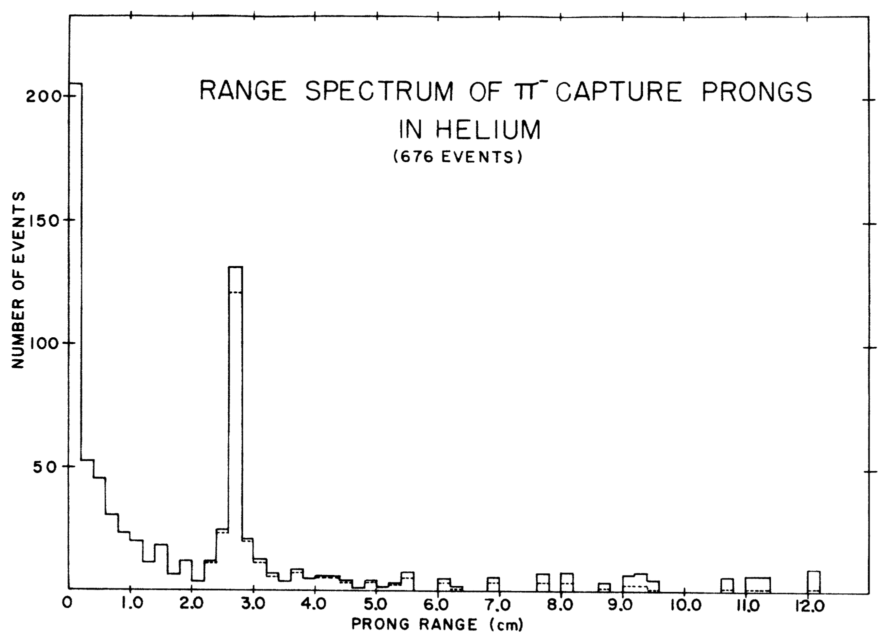

FIG. 2. Range spectrum of capture prongs from a sample of 676 pion "stars" in He^4 (density = 0.141 g/cm^3). The dashed-line histogram represents the spectrum as observed, whereas the histogram in solid lines is corrected for geometric losses. The area under the latter histogram corresponds to 752 events.

the pion mean life. Figure 1 shows a kinematic plot of 134 decays, all having laboratory decay angles $\geq 90°$. These were collected from a total number of stops $N = 18\,540$. This N has been corrected for geometric detection efficiency. Also shown in Fig. 1, as a dashed Gaussian curve, is a calibration μ^+ range spectrum obtained from a sample of 295 π^+ decays at rest. This Gaussian is normalized to the number ($n = 117$) of π^- events with muon ranges between 0.70 and 1.30 cm. On the basis of the experimental μ^+ straggling curve, we can infer for individual events in this group that $v \leq 2\alpha c$. On the other hand, a comparison between the μ^- range histogram and this μ^+ curve shows that the $n = 117$ π^- events are all compatible with decay "from rest." After increasing n by 10% (estimated scanning inefficiency), we conclude that $\tau_c(2\alpha) = (3.6 \pm 0.7) \times 10^{-10}$ sec, where the error allows for scanning losses and detection efficiency, as well as for statistics. This result is in agreement with an estimate made by the Carnegie Institute of Technology group[3] on the basis of a similar study involving 11 π^- decays. The moderation time $\tau_c(2\alpha)$ observed in liquid He is remarkably long when compared with the corresponding time observed[2] in liquid H_2, i.e., $(2.3 \pm 0.6) \times 10^{-12}$ sec.

Turning now to point (b) of this investigation, we show as Fig. 2 the range spectrum of capture prongs. This spectrum, containing 676 observed events, has been corrected for geometric detection efficiency. The by now well-established triton peak[4-6] near 2.75 cm range contains $(19.4 \pm 1.8)\%$ of all capture events, in excellent agreement with reference 4. Further, zero-prong stars (i.e., yielding recoils shorter than ~0.2 mm) account for $(14.9 \pm 1.5)\%$ of the spectrum.

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[2]J. H. Doede, R. H. Hildebrand, M. H. Israel, and M. R. Pyka, Phys. Rev. 129, 2808 (1963).

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[4]M. Schiff, R. H. Hildebrand, and C. Giese, Phys. Rev. 122, 265 (1961).

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ERRATA

FERRIMAGNETIC RESONANCE OF DILUTE RARE-EARTH DOPED IRON GARNETS. J. H. Van Vleck and R. Orbach [Phys. Rev. Letters 11, 65 (1963)].

An unfortunate printing error garbled our equation for the quantity Q_n. It should read:

$$Q_n = -S_z^2(1/2\hbar\omega_{n0})^2 \times\{[(K_2^2 - K_1^2)(\lambda_n^{23})^2 + (K_3^2 - K_1^2)(\lambda_n^{33})^2]^2 - (K_3^2 - K_1^2)^2(\lambda_n^{33})^2 - (K_2^2 - K_1^2)^2(\lambda_n^{23})^2\}.$$

Also, in the preceding equations, $\Delta\omega_S$ and $\Delta\omega_W$ should be replaced by $\hbar\Delta\omega_S$ and $\hbar\Delta\omega_W$, respectively.

We neglected, in addition, to point out that Dillon, at the Kyoto conference on magnetism,[1] gave the first experimental demonstration that the slow rather than the fast relaxing theory applied to the rare-earth doped iron garnets.

[1]J. F. Dillon, Jr., J. Phys. Soc. Japan 17, Suppl. B-1, 376 (1962).

COHERENT PRODUCTION AS A MEANS OF DETERMINING THE SPIN AND PARITY OF BOSONS. S. M. Berman and S. D. Drell [Phys. Rev. Letters 11, 220 (1963)].

In the discussion of situation (iii) the angular distributions specifically given in the text are meant for azimuthally symmetrized observation, i.e., the sum at Φ and $\pi - \Phi$.