Upper Limit to the $A_2 \to \eta' \pi$ Decay Mode*

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(Received 1 September 1972)

An upper limit to the branching ratio $(A_2 \to \eta'\pi)/(A_2 \to \rho\pi)$ is determined at the 90% confidence level to be 0.011.

In a previous publication[1] we reported a measurement of the branching ratio

$$R' = (A_2 \to \eta'\pi)/(A_2 \to \rho\pi). \qquad (1)$$

The result, $R' = 0.07 \pm 0.03$, was obtained by observing the $\rho^0\pi^-$ decay in the channel

$$\pi^- p \to p\pi^+\pi^-\pi^- \qquad (2)$$

and by searching for the $\eta'\pi^-$ decay mode in the channel

$$\pi^- p \to p\pi^-\pi^+\pi^-(\eta^0) \qquad (3)$$
$$\searrow \text{neutrals.}$$

In channel (3) the separation of $p\pi^-\eta'$ events from the background is limited by the measurement errors on the η^0 (missing neutrals) and on the η' $(\eta^0\pi^+\pi^-)$ masses. These errors vary with the "$\eta'\pi^-$" mass, resulting in a rapid increase of the background with this mass. The result for R' given in Ref. 1 was obtained, in a somewhat indirect way, by subtracting from the numbers of events near the η^0, η' masses, the numbers of events in a surrounding control region. Other published determinations[2-6] of the $\eta'\pi/\rho\pi$ branching ratio are shown in Table I. These results are also based, almost exclusively, on a study of channel (3). It is clear that the value of R' is not well determined from these studies.

In this note we report a new study, based on a larger data sample, in which we searched for the $A_2 \to \eta'\pi$ decay mode in $p\pi^-\eta'$ events with the η^0 decaying by a charged mode. These events may contribute to the channel[7]

$$\pi^- p \to p\pi^-\pi^+\pi^-\pi^+\pi^-\pi^0 \text{ (or } \gamma). \qquad (4)$$

In channel (4) the $p\pi^-\eta'$ state should be (and is) clearly separated from background. The data for reaction (4) were obtained in a 5-GeV/c π^- exposure of the 82-in. hydrogen bubble chamber at SLAC. The sample of events analyzed for reaction (4) corresponds to 0.086 ± 0.007 μb/event.

By kinematic fitting and by visual observation of track ionization, 3379 events (290 ± 25 μb) were assigned to channel (4). Assuming the branching ratios[8]

$$r_1 = \frac{\eta' \to \eta^0\pi^+\pi^-}{\eta' \to \text{all}} = 0.454 \pm 0.015$$

and

$$r_2 = \frac{\eta \to \pi^+\pi^-\pi^0 \text{ (or } \gamma)}{\eta \to \text{all}} = 0.289 \pm 0.006^7,$$

the observation of one $p\pi^-\eta'$ event in channel (4) would correspond to a cross section of $0.086/r_1 r_2 = 0.65 \pm 0.06$ μb. We observe 28 ± 8 $p\pi^-\eta'$ events (after subtraction of background under both η' and η) in channel (4) for a cross section of 18.3 ± 5.4 μb.[9] In the same data the cross section for $\pi^- p \to pA_2^- \to p\rho^0\pi^- \to p\pi^+\pi^-\pi^-$ in the region $M(3\pi) = 1.2-1.4$ GeV, $t' = \Delta^2_{pp} - \Delta^2_{\min} < 0.8$ GeV^2 has been found to be 80 ± 5 μb.[10] The observation of one $p\pi^-\eta'$ event in channel (4) in the same mass and t' region would thus correspond to

$$R' = \frac{(0.65 \pm 0.06)}{2 \times (80 \pm 5)} = 0.004 \pm 0.0005.$$

We have found *no* event with $M(6\pi) = 1.2-1.4$ GeV and $t' < 0.8$ GeV^2, without making any cuts on either the η^0 or the η' masses. Taking into account the error on the expected number of events and Poisson statistics, our result is therefore:

$$R' < (0.004 + 1.64 \times 0.0005) \times \ln 10 = 0.011$$

with 90% confidence.

The authors gratefully acknowledge the contribution of the SLAC 80-in. bubble-chamber crew and the scanners, measurers, and programmers of the Illinois high-energy group.

TABLE I. The branching ratio $R' = (A_2 \to \eta'\pi)/(A_2 \to \rho\pi)$.

Incident beam	Experiment	η decay [a] observed	R' [b]	Type of upper limit
3.2 GeV/c π^-	Ref. 2	η_n	0.00 ± 0.08	...
5.0 GeV/c π^-	Ref. 1	η_n	0.07 ± 0.03	...
5.0 GeV/c π^+	Ref. 3	$\eta_n + \eta_c$	$0.04^{+0.03}_{-0.04}$	...
8.0 GeV/c π^-	Ref. 4	η_n	0.15 ± 0.09	...
7.1 GeV/c π^+	Ref. 5	η_n	<0.04	not stated
3.7 GeV/c π^+	Ref. 6	η_n	<0.025	2 std. dev.
4.9 GeV/c π^-	This work	η_c	<0.011	90% confidence

[a] η_n means $\eta \to$ neutrals, η_c means $\eta \to \pi^+\pi^-\pi^0$ (or γ).
[b] When possible, the published results have been updated by using the appropriate branching fractions for η' and η from Ref. 8.

*Work supported in part by U. S. Atomic Energy Commission.

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[1]G. Ascoli *et al.*, Phys. Rev. Letters 20, 1321 (1968).

[2]S. U. Chung *et al.*, Phys. Rev. Letters 15, 325 (1965).

[3]K. Böckmann *et al.*, Nucl. Phys. B16, 221 (1970).

[4]A. R. Dzierba *et al.*, Phys. Rev. D 2, 2544 (1970).

[5]M. Alston-Garnjost *et al.*, Phys. Letters 34B, 156 (1971).

[6]K. W. J. Barnham *et al.*, Phys. Rev. Letters 26, 1494 (1971).

[7]We have not fitted events to the hypothesis $\pi^- p \to p\pi^-\pi^+\pi^-\pi^+\pi^-\gamma$. The majority of such events are expected to be fitted also by the hypothesis $\pi^- p \to p\pi^-\pi^+\pi^-\pi^+\pi^-\pi^0$.

[8]Particle Data Group, Phys. Letters 39B, 1 (1970).

[9]In this study the η mass region is taken to be 520–580 MeV and the η' mass region is taken to be 927.5–987.5 MeV.

[10]G. Ascoli *et al.* (to be published).

PHYSICAL REVIEW D VOLUME 7, NUMBER 1 1 JANUARY 1973

Effects of a Neutral Intermediate Boson on Leptonic Atoms

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(Received 19 July 1972)

The effect of a neutral vector boson on the hyperfine interval of the μ^+-e^- bound system is calculated using Weinberg's SU(2) × U(1) lepton model. A lower limit on the mixing parameter θ is obtained, and some consequences of the additional neutral bosons predicted by the SU(3) × SU(3) version of the model are examined.

Recently, there has been renewed interest in a unified model of leptonic weak and electromagnetic interactions due to Weinberg.[1] This renewal of interest was stimulated by the investigations of 't Hooft and B. W. Lee[2] which indicate that models of this type, where the masses of the mediating weak bosons are generated by spontaneous breakdown of a gauge symmetry,[3] may be renormalizable in the conventional sense. Furthermore, a number of higher-order perturbation calculations have since been performed and shown to be finite.[4] These results all suggest that the model has considerable theoretical interest.

The experimental predictions embodied in Weinberg's model are equally interesting inasmuch as they differ significantly from the predictions of the conventional ($V-A$) theory of leptonic weak interactions. While the available weak-interac-