5. CONCLUSIONS

The vector-meson theory of strong interactions could be tested through measurements of the branching ratios for soft (in the c.m. system) meson radiation in non-forward meson or nucleon scattering at high energies or in antinucleon annihilation at high energies.

Under the assumption that the ω meson is connected with the field that mediates the interactions between baryon currents Eq. (21) can then be used to determine the coupling constant g. If the value obtained in this way is reasonable ($\geqslant$ a few units) one may consider the experiment as a support for the vector meson theory of strong interactions and for the assumption that the ω field is coupled to the baryon current. The value of g can then be considered as the measured value of the renormalized ω-baryon coupling constant.

If the value obtained for g is unreasonably small this could be taken as an evidence against the vector meson theory of strong interactions.

However, it is by no means certain that the relations between fundamental fields and physical particles are so simple as assumed here, but they may be of a complicated and remote character.[3] For this reason the experiments suggested here can only give indications concerning the nature of strong interactions but cannot serve as a firm basis for conclusions.

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Remarks Concerning Possible Higher Resonances in the Unitary Symmetry Model*

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A resonance which "decays" into a meson and one of the $J=\frac{3}{2}^+$ isobars may, according to the unitary symmetry scheme, belong to any one of the irreducible representations **8**, **10**, **27**, or **35**. Even if only a $Y=1$ member of the supermultiplet is detected, it is still possible to determine the dimensionality of the representation by the study of the ratios between the partial widths for decays into different isobar-meson channels.

THERE appears to be a growing amount of evidence to support the identification of unitary symmetry—the invariance under SU_3—as the higher symmetry which underlies charge independence in strong interaction physics.[1] The existing stable particles, the vector mesons, and the low-lying baryon-meson resonances which have been discovered in the past few years may be classified according to the irreducible representations of this group, and it appears that the lowest states of the particles with baryon number $B=1$ belong to the representations **8** and **10**, while the lowest states with $B=0$, the pseudoscalar and vector mesons, belong to **8**. There also appears to be a vector meson belonging to the **1**. It is of some interest to speculate about the existence of resonances with $B=1$ belonging to higher dimensional irreducible representations of SU_3. In particular, we shall be concerned with resonances which "decay" into a meson and one of the known isobars, N_3^*, Y_1^* or one of its other partners in the **10** representation. Since

$$\mathbf{8}\otimes\mathbf{10}=\mathbf{35}\oplus\mathbf{27}\oplus\mathbf{10}\oplus\mathbf{8}\,,$$

it follows that the hypothetical resonance belongs to one of the irreducible representations in the decomposition of this product, and we shall concern ourselves with the identification of the dimensionality of the resonances. In principle, one could just count resonances, but as the isospin multiplets within a unitary supermultiplet are usually split, and as some of the resonances, even if they exist, may be rather hard to produce, it is of some interest to look at some more indirect ways of establishing the dimensionality.

In Table I[2] we list the contents of the relevant super-

TABLE I. Isospin (T) and hypercharge (Y) for various supermultiplets.

Representation	**35**	**27**	**10**	**8**
$Y=2$	$T=2$	$T=1$	$\cdots$	$\cdots$
$Y=1$	$T=\frac{5}{2},\frac{3}{2}$	$T=\frac{3}{2},\frac{1}{2}$	$T=\frac{3}{2}$	$T=\frac{1}{2}$
$Y=0$	$T=2, 1$	$T=2, 1, 0$	$T=1$	$T=1, 0$
$Y=-1$	$T=\frac{3}{2},\frac{1}{2}$	$T=\frac{3}{2},\frac{1}{2}$	$T=\frac{1}{2}$	$T=\frac{1}{2}$
$Y=-2$	$T=1, 0$	$T=1$	$T=0$	$\cdots$
$Y=-3$	$T=\frac{1}{2}$	$\cdots$	$\cdots$	$\cdots$

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[1] See S. L. Glashow and A. H. Rosenfeld, Phys. Rev. Letters 10, 192 (1963) and references cited therein.

[2] The novice in SU_3 will find some simple methods for obtaining the isospin content of irreducible representations, for reducing out products of irreducible representations, and for calculating the generalized Clebsch-Gordan coefficients which appear in the wave functions in this article, in a report written by the author, Argonne National Laboratory, ANL-6729 (unpublished).

multiplets, giving the isospin multiplets for each value of Y, the hypercharge. It is clear from this table that should a new resonance be observed in the reaction

$$\pi^+ + p \rightarrow X^{3+} + \pi^-$$

with the subsequent "decay"

$$X^{3+} \rightarrow N_3^{*++} + \pi^+,$$

this resonance must belong to the sextet of the **35**. From the well-known decomposition

$$\mathbf{8} \otimes \mathbf{8} = \mathbf{27} \oplus \mathbf{10} \oplus \mathbf{10}^* \oplus \mathbf{8} \oplus \mathbf{8} \oplus \mathbf{1},$$

it follows that any resonance which decays into a meson and an isobar, but also decays a significant fraction of the time into a meson and a stable baryon, cannot belong to the representation **35**, since the latter is not contained in the decomposition of $8\otimes 8$.[3] A resonance observed in the reaction

$$K^+ + p \rightarrow X^{+} + \pi^+$$

with the subsequent isobar-meson decay must have $Y=2$ and, consequently, can only belong to **35** or **27**. The **27** would presumably also appear as a resonance in $K^+ - p$ elastic scattering, which the **35** could not do.

More detailed information can be obtained from the decomposition of the resonance internal wave function into the end-product wave functions. We shall only write down the results for a resonance observed in

$$\pi^- + p \rightarrow X^{+} + \pi^-.$$

The expressions are[2]

$$\begin{aligned}
|\mathbf{35};\, T=\tfrac{5}{2},\, Y=1,\, Q=1\rangle
&= -(1/10)^{1/2}|\pi^- N_3^{*++}\rangle + (3/5)^{1/2}|\pi^0 N_3^{*+}\rangle \\
&\quad + (3/10)^{1/2}|\pi^+ N_3^{*0}\rangle,
\end{aligned}$$

$$\begin{aligned}
|\mathbf{35};\, T=\tfrac{3}{2},\, Y=1,\, Q=1\rangle
&= -(1/40)^{1/2}|\pi^- N_3^{*++}\rangle + (1/240)^{1/2}|\pi^0 N_3^{*+}\rangle \\
&\quad -(1/30)^{1/2}|\pi^+ N_3^{*0}\rangle - (5/16)^{1/2}|\eta^0 N_3^{*+}\rangle \\
&\quad + (5/24)^{1/2}|K^0 Y_1^{*+}\rangle + (5/12)^{1/2}|K^+ Y_1^{*0}\rangle,
\end{aligned}$$

$$\begin{aligned}
|\mathbf{27};\, T=\tfrac{3}{2},\, Y=1,\, Q=1\rangle
&= (1/8)^{1/2}|\pi^- N_3^{*++}\rangle - (1/48)^{1/2}|\pi^0 N_3^{*+}\rangle \\
&\quad + (1/6)^{1/2}|\pi^+ N_3^{*0}\rangle - (9/16)^{1/2}|\eta^0 N_3^{*+}\rangle \\
&\quad - (1/24)^{1/2}|K^0 Y_1^{*+}\rangle - (1/12)^{1/2}|K^+ Y_1^{*0}\rangle,
\end{aligned}$$

$$\begin{aligned}
|\mathbf{10};\, T=\tfrac{3}{2},\, Y=1,\, Q=1\rangle
&= -1/2|\pi^- N_3^{*++}\rangle + (1/24)^{1/2}|\pi^0 N_3^{*+}\rangle \\
&\quad -(1/3)^{1/2}|\pi^+ N_3^{*0}\rangle - (1/8)^{1/2}|\eta^0 N_3^{*+}\rangle \\
&\quad - (1/12)^{1/2}|K^0 Y_1^{*+}\rangle - (1/6)^{1/2}|K^+ Y_1^{*0}\rangle,
\end{aligned}$$

$$\begin{aligned}
|\mathbf{27};\, T=\tfrac{1}{2},\, Y=1,\, Q=1\rangle
&= -(1/10)^{1/2}|\pi^- N_3^{*++}\rangle - (1/15)^{1/2}|\pi^0 N_3^{*+}\rangle \\
&\quad + (1/30)^{1/2}|\pi^+ N_3^{*0}\rangle - (16/30)^{1/2}|K^0 Y_1^{*+}\rangle \\
&\quad - (4/15)^{1/2}|K^+ Y_1^{*0}\rangle,
\end{aligned}$$

$$\begin{aligned}
|\mathbf{8};\, T=\tfrac{1}{2},\, Y=1,\, Q=1\rangle
&= -(2/5)^{1/2}|\pi^- N_3^{*++}\rangle - (4/15)^{1/2}|\pi^0 N_3^{*+}\rangle \\
&\quad + (2/15)^{1/2}|\pi^+ N_3^{*0}\rangle - (2/15)^{1/2}|K^0 Y_1^{*+}\rangle \\
&\quad + (1/15)^{1/2}|K^+ Y_1^{*0}\rangle.
\end{aligned}$$

If we assume that for the hypothetical higher dimensional resonances the violation of unitary symmetry primarily affects the phase space and form factors in the decay widths—and there is some support for this assumption[1]—then the above wave functions may be used to predict branching ratios. In particular, we define the ratio

$$R \equiv \frac{\Gamma(X^+ \rightarrow Y_1^{*+} + K^0)}{\Gamma(X^+ \rightarrow N_3^{*++} + \pi^-)} \left(\frac{P_\pi}{P_K}\right)^{2l+1} \left(\frac{P_K^2 + \Lambda^2}{P_\pi^2 + \Lambda^2}\right)^{l}.$$

Here P_K and P_π are the momenta of the K and π in the decays

$$X^+ \rightarrow Y_1^{*+} + K^0,$$
$$X^+ \rightarrow N_3^{*++} + \pi^-,$$

l is the orbital angular momentum in the decay, and Λ somehow reflects the "source size". For the isobar-type resonances Λ has the rather low value of 350 MeV.[1] The predictions for the ratio R which follow from the decomposition are

	R		R
35$(T=\frac{5}{2})$	0	**10**$(T=\frac{3}{2})$	$\frac{1}{3}$
35$(T=\frac{3}{2})$	25/3	**27**$(T=\frac{1}{2})$	16/3
27$(T=\frac{3}{2})$	$\frac{1}{3}$	**8**$(T=\frac{1}{2})$	$\frac{1}{3}$

Tables for other ratios can similarly be constructed. A look at the wave functions shows that the hardest to distinguish are the quartets in **27** and **10**. All ratios are the same in the two cases, except ratios which involve the decay into the η^0, which might be difficult to identify. We have taken care only to discuss ratios between partial widths into isobar-meson channels, since all but the **35** can undergo two-body decay of an unspecified amount.

[3] I am indebted to S. L. Glashow for this observation.