ARCHIVES

PSEUDOSCALAR MESON OF MASS 960 MEV AND SYMPLECTIC EXTENSION
OF SU_3 SYMMETRY

CERN LIBRARIES, GENEVA

CM-P00056965

H. Bacry, J. Nuyts and L. Van Hove

CERN - Geneva

9479 / TH. 471
2 September 1964

According to recent evidence ¹⁾, the quantum numbers of the 960 MeV ($\eta \pi \pi$) resonance ²⁾ appear to be $J^{PG} = 0^{-+}$, $I = Y = 0$. We discuss in the present note whether the ($\eta \pi \pi$) resonance, which has been called X^0 ²⁾, can be accommodated in the symplectic model of SU_3 which we have recently proposed ^{3),4),5)}.

This model introduces two basic SU_3 triplets, one belonging to representation 3 (T^+ , T^0 , T^-) and the other to $\bar{3}$ ($\bar{T}^0$, $\bar{T}^+$, $\bar{T}^-$). The "trions" T and $\bar{T}$ have baryon number one and spin one half. As in all models with SU_3 triplets of integral charge, a new additive quantum number D is defined through the generalized Gell-Mann - Nishijima relation

$$Q = I_3 + \frac{1}{2}Y + \frac{1}{3}D. \quad (1)$$

Okun has proposed to call it supercharge ⁶⁾. Our model incorporates it in a simple Lie group of rank three, for which the most natural choice appears to be the symplectic group in six dimensions Sp_6 . We adopt the version of Sp_6 symmetry ^{4),5)} where D and Y conservation is violated by semi-strong interactions $\bar{Y} + \frac{2}{3}D$ being conserved as required by (1) and where the mass splitting operator has the form

$$\Delta m = \Delta m_1 + \Delta m_2, \quad \Delta m_1 \gg \Delta m_2.$$

Δm is obtained as the $I_3 = Y = D = 0$ part of 6×6 , where $6 = \bar{6}$ is the lowest Sp_6 representation. Its SU_3 invariant part Δm_1 is treated as larger than its SU_3 octet part Δm_2 and is considered to second order, Δm_2 being taken to first order as is commonly done in the octet model.

We have proposed ^{4),5)} to classify the 0^- mesons in a Sp_6 representation of dimension 14, containing the SU_3 submultiplets $8(D=0)$, $3(D=1)$ and $\bar{3}(D=-1)$. Submultiplet 8 should contain π , K and η , submultiplet 3 an isoscalar π'^0 and an isospinor $K'^{+,0}$, whereas $\bar{3}$ of course contains $\bar{\pi}'$, $\bar{K}'$. The discovery of the X meson might suggest rather to put the 0^-

particles in the regular representation 21 of Sp_6 , which has the SU_3 structure

$$21 = 1(D=0) + 8(D=0) + \bar{6}(D=1) + 6(D=-1),$$

and to assign X to the $D=0$ unitary singlet. This is not attractive, however, because the corresponding mass formula (Eq. (5.14) of Ref. 4)

$$3(X - \pi) (\eta - \pi) = 4(K - \pi) (X + \eta - 2K),$$

which includes the effect of $\eta - X$ mixing, is far from being satisfied (this formula is known 7),4) to be well verified by the nine 1^- mesons which we have therefore assigned to the regular representation).

We therefore keep to our assignment of 0^- mesons to the Sp_6 representation 14, and identify X with $\frac{1}{\sqrt{2}} (\pi' + \bar{\pi}')$, which has indeed the correct quantum numbers J^{PG} and I , and verifies in addition $Y + \frac{2}{3}D = 0$, (π' has $Y = -\frac{2}{3}$, $D = 1$). The decay $X \rightarrow \eta \pi \pi$ then proceeds through the D changing semi-strong interactions, with conservation of $Y + \frac{2}{3}D$ as required by the generalized Gell-Mann - Nishijima formula, Eq. (1).

Our assignment of X fixes the remaining $D \neq 0$ pseudoscalar mesons. They are $X' = \frac{1}{\sqrt{2}} (\pi' - \bar{\pi}')$ with $G = -1$, $I = 0$, and $K', \bar{K}'$ with $I = \frac{1}{2}$. The mass of X' should be close to $M_X = 960$ MeV, whereas the K' mass follows from the Sp_6 mass relation 4),5)

$$K' - \pi' = K - \pi.$$

Using the masses themselves or their squares we find approximately

$$M_{K'} \approx 1300 \text{ MeV}, \quad M_{\bar{K}'} \approx 1100 \text{ MeV},$$

which values can be regarded as giving an order of magnitude for the actual mass of K' . The main decay modes of X' and K' are predicted to be into 3π and $K\pi\pi$ respectively, both through D changing semi-strong interactions and with conservation of $Y + \frac{2}{3}D$. From the Q values of the decays one expects X' and K' to have much larger widths than X , the X' resonance being wider than K' .

It may be significant for the validity of our considerations that a $(K\pi\pi)$ resonance of isospin one half has been found with a mass of 1215 MeV⁸⁾ and that there are some indications for a $(\rho\pi)$ resonance with $I = 0$ around 975 MeV⁹⁾. These possible particles, for which the symbols C and H have been proposed, seem to have widths of order 40 and 100 MeV, whereas the width of X is smaller than 12 MeV. If they are confirmed and turn out to be pseudoscalar, a possibility which the available evidence does not exclude, it will be tempting to identify them with K' and X' .

Assuming this identification of K' and X' with existing particles to be justified by future experimental work, one would then have reason to believe in the existence of SU_3 triplets with integral charge, in the violation of the supercharge D by semi-strong interactions, as well as in the possibility to embed SU_3 and D into a higher but more strongly violated symmetry based on the group Sp_6 .

We end by a remark on the production of the new O^- mesons. While they can of course be created in pairs by the very strong interactions which conserve Y and D , single production can also occur through semi-strong interactions with change of D but conservation of $Y + \frac{2}{3}D$. Thus X and X' can be produced singly, all other particles involved in the reaction having $Y = D = 0$. Single production of K' ($\bar{K}'$) is possible in a reaction where all other particles have $D = 0$, under the condition that the latter undergo an over-all change of hypercharge $\Delta Y = -1$ ($\Delta Y = 1$). If the D changing part

H_D of the semi-strong interaction Hamiltonian belongs to a SU_3 triplet, hermiticity combined with isospin conservation requires that it transforms under SU_3 like $\pi + \pi' = \sqrt{2}X$. Since H_D should be rather small and act mainly to first order, one might expect that X production would be favoured over X' production in those reactions in which a single $D \neq 0$ particle is produced. We also note that other effects of H_D are the decays of X , X' and K' , as well as a presumably small amount of $\eta - X$ and $K - K'$ mixing.

REFERENCES

- 1) G.R. Kalbfleisch, U.I. Dahl and A. Rittenberg, Contribution to the 12th International Conference on High Energy Physics, Dubna (USSR), August 1964.
- 2) G.R. Kalbfleisch et al., Phys. Rev. Letters 12, 527 (1964).
M. Goldberg et al., Phys. Rev. Letters 12, 546 (1964).
M. Goldberg et al., Phys. Rev. Letters 13, 249 (1964).
- 3) H. Bacry, J. Nuyts and L. Van Hove, Phys. Letters 9, 279 (1964).
- 4) H. Bacry, J. Nuyts and L. Van Hove, "Symplectic symmetry of hadrons", CERN preprint (June 1964), to appear in Nuovo Cimento.
- 5) H. Bacry, J. Nuyts and L. Van Hove, Contribution to the 12th International Conference on High Energy Physics, Dubna (USSR), August 1964.
- 6) L.B. Okun, Contribution to the 12th International Conference on High Energy Physics, Dubna (USSR), August 1964.
- 7) J. Schwinger, Phys. Rev. Letters 12, 237 (1964), and "A field theory of matter", preprint (1964).
- 8) R. Armenteros et al., Phys. Letters 9, 207 (1964).
- 9) J. Bartsch et al., Phys. Letters 11, 167 (1964).