IC/65/11

INTERNATIONAL ATOMIC ENERGY AGENCY

INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS

P AND C PROPERTIES OF THE $\tilde{U}(12)$ MULTIPLETS

ABDUS SALAM
J. STRATHDEE
&
J. M. CHARAP
P. T. MATTHEWS

1965
PIAZZA OBERDAN
TRIESTE

IC/65/11

INTERNATIONAL ATOMIC ENERGY AGENCY

INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS

P AND C PROPERTIES OF THE $\tilde{U}(12)$ MULTIPLETS

Abdus Salam
J. Strathdee
International Centre for Theoretical Physics

J. M. Charap
P. T. Matthews
Imperial College, London

TRIESTE
4 February 1965

P AND C PROPERTIES OF THE $\widetilde{U}(12)$ MULTIPLETS

A dynamical U(12) symmetry scheme has been proposed for strong interactions recently[1] (Salam, Delbourgo, and Strathdee 1965). This scheme has definite implications regarding parity and charge-conjugation properties of strong-interaction physics and some of these are listed below.

(1) A $\widetilde{U}(12)$ invariant Lagrangian or S-matrix element must conserve parity. To prove this, remark that all $\widetilde{U}(12)$ multiplets are composed from basic quarks $\psi_{\alpha p}$ which transform as

$$\delta\psi_{\alpha p} = i\left(\epsilon^j + \epsilon_5^j\gamma_5 + \epsilon_\mu^j\gamma_\mu + \epsilon_{\mu 5}^j i\gamma_\mu\gamma_5 + \tfrac{1}{2}\epsilon_{\mu\nu}^j\sigma_{\mu\nu}\right)_\alpha^\beta (T^j)_p^q \psi_{\beta q}$$

The parity transformation (P), $\psi \rightarrow \gamma_0\psi$ is part of the general $\widetilde{U}(12)$ transformation. Even after the Bargmann-Wigner equations[2] have been imposed, parity is conserved, since the operator $(\not p - m)$ is P-invariant.

(2) The theory preserves charge-conjugation (C) invariance. To see this, note that in this theory the charge-conjugating anti-symmetrical matrix $C_{\alpha\beta}$ (defined by $(C^{-1})^{\alpha\beta}(\gamma_\mu)_\beta^\gamma C_{\gamma\delta} = -(\gamma_\mu)_\delta^\alpha$, $(C^{-1})^{\alpha\beta} C_{\beta\gamma} = \delta_\gamma^\alpha$) acts as a lowering operator, and $(C^{-1})^{\alpha\beta}$ as a raising operator, for example

$$\psi_{\alpha p} \rightarrow C_{\alpha\alpha'}\bar{\psi}^{\alpha' p}, \tag{1}$$

$$\phi_{\alpha p}^{\beta q} \rightarrow \pm C_{\alpha\alpha'}(C^{-1})^{\beta\beta'}\phi_{\beta' q}^{\alpha' p} \tag{2}$$

under charge conjugation. A $\tilde{U}(12)$ invariant expression such as $\phi_A^B(1)\,\phi_B^C(2)\,\phi_C^A(3)$ transforms into $\mp\,\phi_A^C(3)\,\phi_C^B(2)\,\phi_B^A(1)$ so that $\pm\,\mathrm{Tr}\left(\phi(1)[\phi(2),\phi(3)]_{\mp}\right)$ is an invariant. This particular interaction was considered in a previous paper (1965 b), where the mesons were further assumed to be composites of basic quarks transforming according to (1). This assumption allows only for the + sign in (2), and this is the so-called case of "normal" C-parity ($C\pi^0C^{-1} = +\pi^0$, $C\rho^0C^{-1} = -\rho^0$).

(3) A consistent assignment of parities for the $\tilde{U}(12)$ multiplets is obtained if the irreducible multispinor $\Psi_{AB\cdots}^{A'B'\cdots}$ transforms under P according to the rule,

$$\Psi_{AB\cdots}^{A'B'\cdots}(\underline{p}) \rightarrow (-1)^{\bar{n}}\left(\gamma_0\cdots\gamma_0\,\Psi(-\underline{p})\right)_{AB\cdots}^{A'B'\cdots} \qquad (3)$$

where $\bar{n}$ denotes the number of upper indices (A', B',.....). This gives for the basic multiplets of type (3) the assignments:

$\underline{143}^-$, $\underline{4212}^+$, $\underline{5940}^+$,..... for mesons,

and

$\underline{220}^+$, $\underline{364}^+$, $\underline{572}^+$, $\underline{5720}^-$,..... for baryons.

(These basic multiplets correspond[3] respectively to 36, 189, 405 for mesons and 20, 56, 70 and again 70 for baryons in the SU(6) language.) The $\underline{572}^+$ with multispinor form $\Psi_{[AB]C}$ (symmetry type [2, 1]) has been considered by Salam, Delbourgo, Rashid and Strathdee[4](1965). The $\underline{5720}^-$ is a 4-quark, one anti-quark composite with the multispinor form $\Psi_{[BCDE]}^{A}$. It is a very much more complicated $\tilde{U}(12)$ entity than the $\underline{572}^+$ though the SU(6) structure is identical. We shall consider the decomposition of this new basic multiplet in a separate paper. This is the multiplet which seems to be appearing experimentally.

Experimentally also there seems some evidence for 0^+ particles. These could belong to a $\widetilde{U}(12)$-violating P-wave quark - anti-quark system in which case they form parts of an incomplete <u>4212</u> or <u>5940</u> multiplet occurring together with 2^+ particles. Alternatively there is the possibility that there exists a $\widetilde{U}(12)$ multiplet which is not a simple quark - anti-quark ($q\bar{q}$) composite but is a <u>basic</u> multiplet arising as a $qq\bar{q}\bar{q}$ system (with zero relative momenta as for multiplets in (3)).

REFERENCES

1. DELBOURGO R., SALAM A., and STRATHDEE J. 1965a ICTP 64/11 (to be published); 1965b Proc. Roy. Soc. A (1965)

2. The Bargmann-Wigner equations are discussed together with other aspects of the multispinor formalism in its application to $\widetilde{U}(12)$ calculations in a paper by Salam, Delbourgo, and Strathdee (1965b).

3. The correspondence between $\widetilde{U}(12)$ multiplets and SU(6) multiplets is established through the Bargmann-Wigner equations. As it happens, the 143^- collapses to $35^- \oplus 1^-$ under this process.

4. DELBOURGO R., SALAM A., RASHID M., and STRATHDEE J. 1965 ICTP 65/10