APPENDIX II

$N^{(J,l)}$ is given as follows

i) $J = 0,\ S = 0$

$$N_B^{(0,0)} = \frac{g_1^2}{4\pi}\frac{(M+E)^2}{4}\left(1+\frac{6p^2}{(M+E)^2}+\frac{p^4}{(M+E)^4}\right)\frac{1}{2p^2}Q_0\left(1+\frac{m_x^2}{2p^2}\right)$$

ii) $J = 1,\ S = 0$

$$N_B^{(1,0)} = \frac{g_1^2}{4\pi}\frac{(M+E)^2}{4}\frac{1}{2p^2}\left\{\left(1+\frac{1}{9}\frac{p^4}{(M+E)^4}+\frac{2}{3}\frac{p^2}{(M+E)^2}\right)Q_0\left(1+\frac{m_x^2}{2p^2}\right)+\right.$$
$$\left.+\frac{16}{3}\frac{p^2}{(M+E)^2}Q_1\left(1+\frac{\mu^2}{2p^2}\right)+\frac{8}{9}\frac{p^4}{(M+E)^4}Q_2\left(1+\frac{m_x^2}{2p^2}\right)\right\}$$

where

$$\nu_{in}(1) = p^2,\ E = \sqrt{\nu+M^2}\,.$$

DISCUSSION

FEINBERG: Could you explain about the renormalizability of this theory? I would think that if you use the ϱ meson as a glue, then the theory is not renormalizable.

MIYAMOTO: The definition of renormalization here is somewhat different from conventional renormalization. This ζ meson is also a bound state of a baryon and an antibaryon, and the ζ meson is not the real elementary particle; therefore the renormalizability I used is unconventional.

SYMMETRY OF STRONGLY INTERACTING SYSTEMS WITH ZERO HYPERCHARGE

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(presented by A. M. Baldin)

Some time ago one of the authors (A.M.B.) of this note considered [1] the possibility of the existence of particle quadruplets with near masses and identical properties, differing only by the value of the isotopic spin ($T = 1$ and $T = 0$). Recently Glashow [2] analysing new experimental data on the π-meson and π-meson-hyperon resonances once more drew attention to the puzzling similarities in the properties of the particles relating to the multiplets with $T = 1$ and $T = 0$. The authors of the present note believe that these coincidences of the particle properties can not be accidental and suggest below one possible interpretation of them.

From presently available experimental data it follows that to each multiplet with $T = 1$ one can put in correspondence a singlet with $T = 0$ having the same quantum numbers and a near-lying mass. Among them one finds the newly discovered ζ and η-mesons, [3,4] earlier studied ρ and ω-mesons, [5,6] Y_1^* and Y_0^* resonances [7,8] and at last Σ and Λ-particles. For the sake of convenience we present data, relating to these particles in Table I.

As it is clear from the table the only exclusion from the discussed rule is the π-meson which for the time being has no counterpart π_0^0-meson. We shall return to this point later but now let us consider the table.

It is well known that in general strong interactions are strongly dependent on the isospin value of the interacting system. The striking example is the π-N interaction. Seemingly this fact contradicts the existence of any symmetry leading to the degeneracy of the properties of the physical systems with respect to the isotopic spin value. However looking at the table more attentively one notices that all the particles in it have one property in common: the hypercharge Y*) equal to zero.

This characteristic distinguishes them from the πN-system for which $Y = 1$ and also from $K\pi$, $K\Sigma$, $\pi\Xi$ systems. The zero value of the hypercharge for the system, degenerated with respect tot he isotopic spin, might be very significant and point to a very important role, which hypercharge plays in strong interactions. The authors think that the hypercharge has a deeper physical meaning than the " strangeness " number, a point emphasized already by Schwinger [9]. On the basis of the available data the following conclusion can be drawn which the authors want to consider as a kind of rule: hypercharge is such a characteristic of the system which switches on strong dependence of all its properties on the isotopic spin. When hypercharge equals zero, the (hyperneutral system) dependence on the isotopic spin value disappears and degeneracy takes place. First of all, from this assertion follow the near equality of the masses of the particles with $Y = 0$ relating to the different isotopic multiplets and the identity of all other quantum numbers. This could serve as an indication for experimental search in the cases where these quantum numbers (spin, parity) are not certain. In particular one should have equal parities for Σ and Λ-particles, spin $s = 3/2$ for the Y_0^*-resonance. The identity of the properties must persist also for all particles (resonances) to be discovered. An interesting conclusion can be drawn with respect to the $\Sigma\pi$-system. Here near lying resonances should be observed in the states with$T = 0, 1, 2$. The predictions of the opposite nature follow for $K\pi$, $K\Sigma$, $\pi\Xi$-systems. In these cases there must be a strong dependence in the behaviour of the system on isospin value. Resonances should occur in states of particular isotopic spin. Indeed a K^*-resonance is observed in the state with $T = 1/2$, and there is no indication of the near lying resonance with $T = 3/2$. Because of the close connection which exists between the masses of the bound states (positions of the resonances) and the properties of the S-matrix elements (positions of the poles), the latter must have an analogous dependence on the hypercharge values. Hence one gets immediately that cross-sections for the inter-

TABLE I

$T = 1$				$T = 0$				
Particle	m_1 (MeV)	s	P	Particle	m_0 (MeV)	s	P	$\frac{m_0 - m_1}{m_1}$
π	140	0	-1	π_0^0 (?)				
ζ	575	?	?	η	550	0	—	4.3%
ϱ	750	1	-1	ω	780	1	-1	4%
Σ	1190	$1/2$		Λ	1115	$1/2$		6.3%
Y_1^*	1385	$3/2$		Y_0^*	1405			1.4%

(*) The hypercharge $Y = S + B$, where S is the " strangeness ", B the baryonic number.

actions in the $\overline{N}N$ and K^-N systems must be degenerate in isotopic spin (both in elastic and inelastic channels). An excellent confirmation of this statement is the equality of $\bar{p}p$ and $\bar{n}p$ cross-sections in all measured energy ranges.[10] One can easily, show that this follows from the equality of the scattering amplitudes for $T=1$ and $T=0$ states. Unfortunately available data on K^-N interaction are not complete enough to make such a detailed analysis.

A constraint on the symmetry comes from the condition that the kinetic energy of the process must be large in comparison with the mass splitting of quadruplet components. The non-observance of the last condition may be of importance in consideration of the inelastic channels of K^-p interaction at small energies. We have used the 0_4-group as an example of the mathematical formulation of the symmetry of hyperneutral systems.[13] To define the operator Y we have to turn to a space of more dimensions for which the space of R_y is a subspace relating to $Y=0$. Another subspace with $Y \neq 0$ should be the space where R_3 acts. The existence of the degenerate quadruplets ζ, η; ρ, ω makes it plausible that they transform as vectors in 4-space i.e. belong to the representation (½, ½). In analogy it is tempting to assume that the π-meson also transforms as a 4-vector (*); that it has a fourth component π_0^0, similar in all respects to the π, besides being isoscalar as has been suggested earlier [1]. The non-discovery of π_0^0, despite numerous efforts [11] may only indicate that its interaction with hypercharged systems is weaker than it was usually assumed. This is no wonder because in the case of hypercharged systems our symmetry does not work.

Recently interest in the different types of generalized symmetries was revived.[14] The symmetry discussed above has in our opinion the advantage of being nearly as accurate as the isotopic invariance and having a well defined domain of validity ($Y=0$).

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DISCUSSION

WEINBERG: These relations among S-matrix elements in a high energy limit are expected to hold independently of any symmetry.

BALDIN: This is not an objection; you have a different explanation of the same data, but there are similar relations at low energy, for example $\bar{p}+p \rightarrow \bar{n}+n$ is very small.

WEINBERG: I am not objecting to your symmetry, but to the evidence you quote for it. Since the dominance of the Pomeranchuk-Regge trajectory provides a reasonable dynamical explanation of these relations, they can't be used as an argument for a new symmetry.

BALDIN: This argument may be weaker than I presented it. Yes, I agree.

MORAVCSIK: I was under the impression that the evidence for the non-existence of the π_0^0 meson from simply low energy pion-nucleon interaction measurements is rather conclusive by now. Isn't it really so?

*) It is also possible to describe the π- field by a self-dual tensor which has only three components [12].

BALDIN: I believe that it is impossible to prove that something does not exist. You can only prove that in such and such conditions something does not exist and as an example of this it may be one has looked for π_0^0 in hypercharged systems but not in hyperneutral systems. In the hypercharged system maybe it interacts very weakly.

YAMAGUCHI: I might add one remark. If you say, that the interaction has a particular symmetry for zero hypercharge but no such symmetry for $Y \neq 0$ hypercharge, this means an awful sort of non-locality or whatever you might call it.

BALDIN: About the field theoretical discussion of this speculation, Prof. Yamaguchi is quite right. There are some difficulties, but I did not mention it because it would necessitate an additional discussion on this point, so I only discussed the relation between matrix elements and the group theoretical aspect. I prefer not to be involved in discussions of the field theoretical aspect.

BLUDMAN: Concerning the absence of the π_0^0, it is not essential that the pion be the assigned to the vector representation; it could be assigned to the self-dual tensor representation.

BALDIN: Yes, I mentioned it in my talk but very briefly. I agree with this comment that it is possible to build all this scheme without the π_0^0, but it is worthwhile to introduce π_0^0 from an aesthetical point of view; the pion is the lowest state among hyperneutral systems which all seem to be 4 vectors.

FEINBERG: I would like to ask Prof. Baldin what he would regard as a crucial test of his suggestion?

BALDIN: A crucial test of this suggestion would be quite simple. If somebody finds that the spin of the ζ particle is different from that of the η then this symmetry is ruled out. There are also some selection rules which follow from this symmetry.

GLOBAL SYMMETRIES AND WEAK INTERACTION SELECTION RULES

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I. INTRODUCTION

Various global symmetry schemes have been proposed so far, which have very different consequences. Indeed a global symmetry is an attempt to unify the I-spin and the Y-charge conservation laws; it is therefore a natural question to ask whether the selection rules for E. M. and weak interactions which are expressed in terms of T and Y, could not be unified also. For electromagnetism this has been discussed in ref.[1, 2] In this paper we will examine implications of global symmetry on weak interaction selection rules.

We start from the following remark: if T_3, T^2 and Y are the only conserved quantities, the global symmetry group must be of rank 2, for otherwise some processes which have been observed would be forbidden [3]. (This was for instance the case for the so-called doublet approximation). Groups of rank two are $A_2(= SU_3)$, $B_2 = C_2(=0_5 = Sp_2)$, $D_2(= 0_4)$, $G_2(=$ exceptional group$)$, U_2. (A_2, $B_2 = C_2$ and G_2 are simple and D_2 is semi-simple; here we shall not consider D_2 and U_2). To every semi-simple group is intimately associated a discrete group, the so-called *Weyl-group* S which determines its internal structure. The groups S corresponding to D_2, A_2, $B_2 = C_2$, G_2 are d_2, d_3, d_4, d_6, where d_n is the dihedral group of order $2n$ ($a^n = b^2 = e \;\; ab = ba^{n-1}$). The lattices of D_2 and $B_2 = C_2$ have therefore a quadragonal, those of A_2 and G_2 a hexagonal structure. In a previous paper [4] we proposed the following:

Postulate (S-principle): the selection rules for weak interactions shall be invariant under the transformations of the group S. We may express this in an alternative way by saying that the WI-Hamiltonian