CUTKOSKY: The answer to the first question is, I believe, no. As to the second question,

$$\alpha = (1+\tfrac{1}{3}\sqrt{5}\tan\theta)^{-1}$$

BREITENLOHNER: I would like to make a remark on R-in variance mentioned by Cutkosky. In my opinion the main reason to introduce this invariance is to distinguish the two equivalent octets in the (baryon octet)·(meson octet) direct product, but this gives some trouble as $\mu_n = 0$. Another possibility is to assume an interaction symmetric in the two octets and this is plausible since the interaction is mediated by vector bosons which couple in the same way in both octets. This gives no such trouble.

CUTKOSKY: The trouble with R invariance is that is gives an attraction in both of the 8-dimensional multiplets, and also in the one-dimensional one. So that you start out assuming that you have eight baryons and you end up finding more than eight. Of course, this is based on a picture in which we do not assume any gluons or things like that. I mean, it is only particles which come out that are put in at the beginning.

NE'EMAN: In our calculations of some branching ratios we have generally been able to get the right branching ratios with mixtures of the two couplings, F and D, something like the θ Dr. Cutkosky was describing. It did not come out as one to one, if the $\theta = 45°$ represents something like that, but a mixture for the case of a coupling of the vector meson with the baryons was generally necessary. When you work with a vector meson coupling with mesons you generally take only F, because then R is the same thing as charge conjugation, and you have to keep within this coupling.

CUTKOSKY: Well, the angle which we think works best for the pseudoscalar meson-baryon coupling is something like 30° actually.

NE'EMAN: Just one other point about the comparison with the Sakata model for annihilations into two mesons. The Rehovoth group has proved an identity for the Sakata model showing that the annihilation of $p\bar{p}$ into $\overline{K^0 K^0}$ cannot produce an odd charge conjugation pair. As the experiments show that what is produced is a $K_1{}^0 K_2{}^0$ system, the Sakata model seems to fail in this respect. I would just like to ask the experimentalists what is the present situation for the spin of the cascade, because that would probably be crucial for the knowledge about the two models.

YAMAGUCHI: Yesterday I asked specifically this question and it seems it is not settled.

CUTKOSKY: If you believe the Sakata model, then you get the Σ belonging to a sextet which lies very close to the triplet, and in the strangeness zero channel there are two doublets separated by a mass difference comparable to the $\Lambda\Sigma$ mass difference. And then you will have to assume that you have some unsymmetrical forces comparable to the Λ-nucleon mass difference. So these two doublets will certainly be strongly mixed, so I do not think that one could realistically expect, if the Sakata model were right fundamentally, that this selection rule would work.

RENORMALIZABLE COMPOSITE MODEL OF ELEMENTARY PARTICLES

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(presented by Y. Miyamoto)

Recent discovery of many resonance levels of baryons and bosons stimulates an interest in the structure of elementary particles. There is the possibility that baryon isobar levels may be explained in terms of Chew-Low type theory (namely p wave $\pi(K)$ meson-hyperon resonances) and the Takeda-Ball-Frazer theory. On the other hand (ω, ρ, K^*) multiplet with spin 1 may be interpreted to be the p wave resonances among (π, K, π_0') multiplet with spin 0. But, as for this model, the coincidence of energy levels of (ω, ρ, K^*) seems to pre-suppose a rather complicated mechanism (c.f. ω and ρ are K-$\bar{K}$ bound states and K^* is K-π p wave resonance). Then the most simple model is the Fermi-Yang-Sakata model. In this model π, ω etc. mesons are compound states of P, N, $\Lambda^{(*)}$ and their antiparticles.

(*) We abbreviate (P, N, Λ) by **B**.

We examine the problem of what is the gluon that binds the baryons and antibaryons. It may be a mysterious force of unknown type, but, to make the situation clearer, we try to take the rather conservative view-point that only the cloud mesons can be gluons. Maki and Nambu introduce an unrenormalizable Fermi type interaction between baryons and antibaryons to construct various bosons. We assume that π, ω, ρ, ζ etc. are bosons which are bound states of B and $\bar{B}$, and then the theory is renormalizable. It is well-known that in the nucleon-nucleon potential, there is quite a strong L-S force with the magnitude comparable to Fermi-Yang potential. Machida and Minami discuss the possibility of the identification of the hard core of N-N force with charge conjugate Fermi-Yang potential.

We assume that ζ vector meson is the principal gluon which creates nine vector bosons, of which eight are Ohnuki, Ogawa, Ikeda and Yamaguchi's octet and one is ζ itself; ζ also creates nine pseudoscalar bosons, of which eight are Ohnuki *et al.*'s octet and π_0 meson. If we also introduce both octets as gluons of baryons and antibaryons, the mass of ζ is lighter than those of vector octet. (Appendix I). It is easily shown that the mass of the vector octet lies higher than the pseudoscalar octet under the assumption of vector (or scalar) ζ meson. If all bosons are not elementary particles, but really pure compound states of baryons and antibaryons, the mass levels of bosons should be determined analogously to Chew-Mandelstam-Zachariasen's self consistent theory of p wave π-π resonance. Our approach corresponds to unsubtracted dispersion relation for B-$\bar{B}$ scattering, which can give us the relation between mass and coupling constant. The dispersion integral converges by Regge pole hypothesis of elementary particles, as shown later.

We employ N/D method for the evaluation of the mass levels of the vector and pseudoscalar octets, and further make an approximation that $N^{(J,l)}$ = Born approximation of B-$\bar{B}$ scattering amplitude for the various states of definite total angular momentum J and orbital angular momentum l. D is defined as follows

$$D_{(\nu)}^{(J,l)} = 1 - \frac{1}{\pi}\int_0^\infty \frac{d\nu'}{\nu'-\nu}\sqrt{\frac{\nu'}{\nu'+M^2}}N_B^{(J,l)}(\nu') \qquad (1)^{(*)}$$

(*) M = baryon mass.

The mass levels of bosons can be determined from zeros of D. We introduce a cut-off at $M(2M)$. The meaning of the cut-off is as follows; if we introduce a Regge pole hypothesis of elementary particles for bosons, the integral is easily shown to converge except for a vacuum pole, since the integrand tends to $E^{l-\alpha(0)}/\log E$ at $E\to\infty$. It is assumed that all bosons behave at high energy ($\sim M$) as if they were Regge poles. We take into account only S wave. Our method is shown to be an approximate solution to the Bethe-Salpeter equation. If the Bethe-Salpeter amplitude is replaced by $\gamma_5 + a\gamma_5\gamma_4$ for pseudoscalar bosons, and $(\vec{\gamma_s} + a\gamma_4\vec{\gamma_s})$ for vector bosons, B-S equation is reduced to Dyson's integral equation for the vertex, which can be shown to be equivalent to Eq. (1).

Numerical results are shown in Table I.

TABLE I

The coupling constant of ζ meson ($m_\zeta = 790$ MeV)

	$g_1^2/4\pi$ (coupling coust. of ζ meson)
pseudoscalar	5.5 (1.4)
vector (S wave only)	6.2 (1.7)

Numerical value with (without) parenthesis corresponds to cut off $M(2M)$. If pseudoscalar octet is introduced as gluons, in addition to ζ meson, $g_1^2/4\pi$ becomes 0.7 (0) times smaller for ps. octet and becomes 1.1 (1.3) times larger for v. octet.

APPENDIX I

We assume the following Hamiltonian between baryons ψ_i (P, N, Λ) and ζ, ρ, π etc. mesons.

$$ig_1\bar{\psi}^i\gamma_\mu\psi_i\phi_\mu + ig_2\bar{\psi}^i\gamma_5\psi_i\Pi''_0 + if_1\bar{\psi}^i\gamma_\mu\psi_j\phi^j_{\mu i} + if_2\bar{\psi}^j\gamma_5\psi_i\Pi^i_j$$

The potential between baryons and antibaryons mediated by octet gives factors $-1/3$ and $8/3$ for octet- and singlet-states respectively.

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