On the Tenfold Way (*)

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In a recent paper (1) published in this journal we predicted the existence of a $Y = -1$ (strangeness $= -2$) $T = \frac{1}{2}$ baryon with mass 1520 MeV and a $Y = -2$ (strangeness $= -3$) $T = 0$ baryon with mass 1640 MeV, both particles with spin $J = \frac{3}{2}^+$. This result followed from three assumptions:

i) The 3-3 pion-nucleon resonance and the $Y^*_0(1385)$ belong to a ten-dimensional representation of $SU(3)$.

ii) The unitary symmetry mass formula (2)

$$m = m_0 \left[ 1 + a Y + b \left( T(T+1) - \frac{1}{2} Y^2 \right) \right],$$

is applicable to the $J = \frac{3}{2}^+$ baryon isobars.

iii) The dimensionless parameters $a$ and $b$ in eq. (1) take common values for the eight-dimensional representation to which $N^*, \Xi, \Lambda, \Sigma$ are assumed to belong, and for the ten-dimensional representation of baryon isobars.

Subsequently, the existence of a $\pi \Xi$ resonance with $T = \frac{1}{2}$ and mass 1530 MeV has been established in a Brookhaven-Syracuse collaborative experiment (a) and in a U.C.L.A.-Berkeley collaborative experiment (b). Because of the interest in the representation 10 cau-

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(1) S. L. GLASHOW and J. J. SAKURAI: Nuovo Cimento, 25, 337 (1962). See especially the Appendix. In this reference, we stressed the representation 27 rather than the 10 partly because we wished to include both the $Y^*_0(1385)$ and the $Y^*_2(1405)$ in the same $J = \frac{3}{2}^+$ unitary supermultiplet. Now that the $Y^*_2$ seems to be an $s$-wave $KN$ bound state of the Dalitz-Tuan type (see e.g., T. AKIRA and R. H. CAPPS: Phys. Rev. Lett., 8, 457 (1962)), the representation 27 is no longer so appealing.


sed by this remarkable discovery, we wish to add a few comments to our earlier work.

a) In discussing the mass formula, we failed to note that, because of the linear relation $T = 1 + \frac{1}{2} Y$ among the multiplets contained in the representation 10, the quadratic terms in eq. (1) are cancelled, and the mass formula simplifies to

$$m = m_0' (1 + a' Y),$$

as first recognized by Gell-Mann (4). Once the masses of $N_0^*$ and $Y_1^*$ are known, assumption iii) is no longer
required in order to predict the masses of the $Y = -1$ and $Y = -2$ states. Taking $m(N_0^*) = 1238$ MeV and $m(Y_1^*) = 1385$ MeV, we find for $m(\Xi_0^*)$ the predicted mass 1532 MeV, and for the mass of the $Y = -2$ isotopic singlet state we obtain 1679 MeV.

b) Since the $K\Sigma$ threshold is near 1820 MeV, the predicted $Y = -2$ baryon must be stable against decay via strong or electromagnetic interactions. It is expected to decay by $\Delta Y = 1$ weak interactions, either non-leptonically (6),

$$Z^- \rightarrow \pi + \Xi, \quad K + \Lambda, \quad K + \Sigma$$

or leptonically,

$$Z^- \rightarrow \Xi^0 + e^- + \nu, \quad \Xi^0 + \mu^- + \nu';$$

but we cannot exclude the possibility of such $\Delta Y = 3$ decay modes as

$$Z^- \rightarrow n + \pi^-.$$

We take the liberty of naming the conjectured baryon $Z^-$ because we believe it will be the last "stable" baryon to be discovered. (Earlier Gell-Mann (4) called such a hyperon $\Omega^-$.)

c) Perhaps the mass formula, eq. (2) is applicable to the imaginary parts of the masses of the 10, as well as to the real parts. This possibility did not arise for the octets of baryons and pseudoscalar mesons, all of which are stable against strong interactions. This yields a relation among the decay widths of the $\Xi^0$ baryon isobars. Fitting $\Gamma(N_0^*) = 90$ MeV and $\Gamma(Z) = 0$, we predict $\Gamma(Y_1^*) = 60$ MeV and $\Gamma(\Xi_0^*) = 30$ MeV.

d) It is remarkable that a peculiar event observed by Eisenberg (7) in 1954 may be interpreted as the decay of a $Z^-$ hyperon of mass $\sim 1690$ MeV. Eisenberg argued that the mass of the new hyperon * would be 1440 MeV if a $n + K$ decay mode were assumed and 1615 MeV if a $\Lambda + K$ decay mode were assumed. A close reading of his paper reveals that his event is also consistent with the decay mode

$$Z^- \rightarrow K^- + \Sigma^0,$$

with a very small ($\sim 5$ MeV) $Q$ value (8). (This interpretation was not suggested in 1954 because the charge-triplet character of the $\Sigma$ hyperon had not then been firmly established.) With this new interpretation, the mass of the Eisenberg hyperon becomes 1690 MeV, in excellent agreement with the value predicted by the mass formula.

e) The conjectured $Z^-$ hyperon could be produced by strong interaction in such reactions as

$$Z^- \rightarrow K^- + \Sigma^0.$$