Remarks on Mass Spectrum of Decuplet Baryons. II

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May 28, 1964

In the preceding note 1) (which is hereafter referred to as I) we analysed $SU_3$ mass relations for the baryon decuplet and octet states. In this note we compare the results with some experimental data and also point out for the mass spectrum of those states certain other marked properties which are outside the $SU_3$ conception.

The mass formula for the decuplet was given in I by

$$m=m_0' - b' Y + d'(Y^2 - 1) - e' Q + f'(Q^2 - 1). \quad (1)$$

First we derive from this the mean mass over each isomultiplet

$$\langle m \rangle = m_0' - b'_i Y + d'_i (Y^2 - 1),$$

which implies

$$Q = \langle N^* \rangle = 3 (\langle S^* \rangle - \langle Y^*_1 \rangle). \quad (2)$$

The statistics in the mass determination of $N^*$, $Y^*_1$ or $S^*$ usually do not distinguish its charge states, and thus the observed mass for each of them as given in the literature is regarded approximately as the average over isospin components. Taking the values tabulated by Roos 2) we then have (in Mev)

$$\langle N^* \rangle = 1237, \quad \langle Y^*_1 \rangle = 1382 \pm 2,$$

$$\langle S^* \rangle = 1533 \pm 3. \quad (3)$$

With the use of them Eq. (2) yields $Q = 1690 \pm 10$ in agreement with observation. Recent measurement 3) for $Y^*_1$ has re-
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solved the masses of its charged states such that \( Y_1^{*+}=1375\pm3.9 \) and \( Y_1^{*-}=1392\pm6.2 \). These allow to evaluate the parameter \( e' \) in (1):

\[
e' = \frac{1}{2} (Y_1^{*-} - Y_1^{*+}) = 8.5\pm3.5,
\]

while \( f' \) in (1) can be estimated, through \( f'/3=(Y_1^{*+}+Y_1^{*-})/2-\langle Y_1^* \rangle \), only roughly to be \( f'=4.5\pm12 \).

For the broad \( N^* \), the isotopic mass splittings have not been measured directly. However, Boldt et al.\(^9\) obtained for the \( N^* \) in the process \( K^+ p \rightarrow K^0 + \pi^+ p \) mass value fairly smaller than usual, which is to be interpreted to give \( N^{*++}=1212\pm8 \). This is not inconsistent with \( N^{*++}=(3e'-5f')/2 \), following from the formula (1), with the above values of \( N^{*+} \), \( e' \) and \( f' \).

While the \( SU_3 \) mass formulas do not concern the mass relationship between octet and decuplet of baryons, we now present just such relation. We calculate the mean baryon mass \( \langle B \rangle \), as defined in I, by inserting the observed mass values of eight baryons taken from Roos' Table\(^2\) to get \( \langle B \rangle=1151.2\pm0.2 \). Similarly we calculate the mean decuplet mass \( \langle B^* \rangle \), using the values (3) together with the observed \( Q^- \) mass, to get \( \langle B^* \rangle=1385\pm2 \). Then we find that the spacing between both values is equal to the spacing between two isosinglet mesons, \( \omega \) and \( \eta \), within experimental accuracy:

\[
\langle B^* \rangle - \langle B \rangle = m_\omega - m_\eta = \omega - \eta = \mu,
\]

where \( \mu \) designates the unit defining the equal-spacing rule\(^3\) for isosinglet mesons, i.e., \( \mu=\omega - \eta = \varphi - \omega = 235 \text{ Mev} \). Note also that the mass formulas (2) and (3) of I imply

\[
\langle B \rangle = \langle A + \langle \Sigma \rangle \rangle / 2, \quad \langle B^* \rangle = \langle Y_1^* \rangle,
\]

if we neglect smaller quantities \( d, d' \) and \( f' \).

Similarly, if we assume the "second" resonances \( N^{*0}_K(1515), Y^*_K(1519), Y^*(1660) \) and \( \Xi^{*0}_K(1770) \) as forming \( J^P=3^-/2 \) octet, its mean mass becomes \( \langle B^*3^-/2 \rangle = 1634\pm14 \), so that the relation

\[
\langle B^* \left( \frac{3^-}{2} \right) \rangle - Y_0^* \left( \frac{1^-}{2} \right) = \mu
\]

is again satisfied within experimental error, where \( Y_1^* \) is the resonance at 1405 Mev considered as unitary singlet.

As previously pointed out\(^6\) the masses of various isosinglet mesons are integer multiples of the subunit \( \mu_0 = \mu/3 = 78.3 \text{ Mev} \), e.g.,

\[
\omega = 7\mu_0, \quad \varphi = 10\mu_0, \quad \varphi = 13\mu_0,
\]

and further \( f=16\mu_0, \quad ABC=4\mu_0, \quad 5\mu_0, \quad \sigma = 5\mu_0, \quad \sigma \) is the presumed \( T=0 \) \( 0^+ \) dipion resonance at about 390 Mev.\(^7\) With the use of this unit,

\[
\langle \Sigma \rangle - A = \mu_0
\]

is satisfied within experimental accuracy,\(^6\) meaning that the parameter \( c \) in the baryon formula (3) of I should be \( c=\mu_0/2 \). The above relations (4)-(7) suggest the basic role of the unit \( \mu \) or \( \mu_0 \) in the mass quantization of mesons and baryons, which does not follow from the broken \( SU_3 \) symmetry but may be compatible with it.

6) T. Takabayasi, Nuovo Cim. 30 (1963), 1500.