27 → B + P Decays of $\frac{3}{2}^{+}$ Baryon Resonances in Broken $SU_3$ Symmetry (').

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(ricevuto il 20 Giugno 1964)

Summary. — The decays of $\frac{3}{2}^{+}$ baryon resonances comprising the 27-plet representation of unitary symmetry, into baryon and pseudoscalar meson octets, is considered under the assumption of a first-order breakdown of the symmetry. There are 24 possible decays which are described in terms of 7 parameters. This leads to 17 coupling constant sum rules.

1. — The possible existence of baryon resonances with $J=\frac{3}{2}^{+}$ belonging to the 27-fold representation of $SU_3$ symmetry has recently attracted some attention (1).

In this note, we are interested in the first-order corrections to the coupling constants for the decay of these resonances into a baryon octet with $J=\frac{1}{2}^{+}$ and a pseudoscalar meson octet ($J=0^{-}$), arising from $SU_3$-violating strong interactions. We find that there are 24 distinct decays, ignoring energy-momentum considerations which may prohibit some decays. There are 7 parameters in the theory: the $SU_3$-invariant coupling constant $G_0$ and 6 mixing parameters, the latter arising as a result of the assumption of a first order violation of $SU_3$ symmetry (i.e., we are assuming that the symmetry-breaking interaction transforms like $T^3_3$).

The matrix element for the symmetry-breaking part of the $27 \rightarrow B + P$
transition may be written as

\begin{equation}
M \sim \langle 8 + 8 | T_3^a | 27 \rangle.
\end{equation}

This may be rewritten as follows:

\begin{equation}
M \sim \sum_{m} \langle 8 + 8 | m \rangle \langle m | T_3^a | 27 \rangle,
\end{equation}

where we have introduced the unit operator:

\begin{equation}
1 = \sum_{m} | m \rangle \langle m |.
\end{equation}

The only allowed states \(| m \rangle\) are those which are common to \(8 \times 8\) and \(8 \times 27\). These are \(8, 10, \bar{10},\) and \(27\). Now \(8\) occurs twice in the direct product of two \(8\)'s and so does \(27\) in \(8 \times 27\).

Thus, we may write the following expression for the \(27 \to B + P\) coupling constants (to the lowest order in symmetry-breaking interactions) (2):

\begin{equation}
G = \alpha_{27}^8 \sigma_0 + \sum_{m,n} \alpha_{m,n}^8 \beta_{m,n}^{27} G_{mn},
\end{equation}

with \((m, n) = (8, 8), (8, 2), (10, 10), (10, 27), (27, 27),\) and \((27, 272)\).

\(\alpha\) and \(\beta\) are the appropriate C-G coefficients for \(8 \times 8 \to m\) and \(8 \times 27 \to n\), respectively.

Equation (3) yields a set of 24 relations (these are the only possible relations which are allowed by conservation of I-spin and hypercharge). These relations are expressed in terms of 7 parameters: the \(SU_3\)-invariant coupling \(G_0\) and 6 mixing parameters: \(G_{s_8,s_8}, G_{s_8,s_8}, G_{10,10}, G_{10,10}, G_{27,27},\) and \(G_{27,27,27}\).

The 24 equations are:

\begin{enumerate}
\item \(G(\frac{3}{2}, 1 \to N\pi) = \sqrt{\frac{1}{2}} a - \sqrt{\frac{5}{48}} d + \sqrt{\frac{5}{448}} f - \sqrt{\frac{3}{64}} g,\)
\item \(G(\frac{3}{2}, 1 \to \Sigma K) = \sqrt{\frac{1}{2}} a + \sqrt{\frac{5}{48}} d + \sqrt{\frac{5}{448}} f - \sqrt{\frac{3}{64}} g,\)
\end{enumerate}

\(^{(2)}\) V. Gupta and V. Singh have recently considered the decuplet \(\frac{3}{2}^+\) decays into \(B + P\), using the \(\epsilon\)-spurion \(\epsilon\) technique: \textit{Sum rules for the decay of the baryon decuplet into baryon and meson octets in broken \(SU_3\) symmetry} (Institute for Advanced Study preprint). Other references may be found there.

\(^{(2)}\) Specifically, \(\beta\) couples the \(I=0\) and \(Y=0\) part of the \(8\) to the \(27\); The C-G coefficients are taken from J. J. De Swart: \textit{Rev. Mod. Phys.}, 35, 916 (1963).