POSSIBLE VALUE OF THE Ω^--BARYON QUADRUPOLE MOMENT

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The isobar model for π-meson photoproduction on nucleons predicts the presence of a small fraction of $N^{*+} \rightarrow p + \gamma$ decays with emission of γ-quanta of the electric quadrupole type. The electric quadrupole moments for baryons from the decuplet are calculated by employing the simplest of possible transformation properties of the electric quadrupole moment operator relative to the SU(6) group (405-plet).

IN radiative decay of the nucleon isobar $N^{*+} \rightarrow p + \gamma$, the total-angular-momentum and parity conservation laws allow the emission of a magnetic dipole or electric quadrupole γ quantum. Investigation of the photoproduction of pions on nucleons near energies corresponding to the first resonance, shows, within the limits of existing experimental accuracy, that only a γ-quantum of the magnetic dipole type is emitted in the $N^{*+} \rightarrow p + \gamma$ decay. Yet the isobar model[1], which describes satisfactorily the aggregate of all the data concerning photoproduction of pions in a wide range of energies, predicts a small admixture (of the order of 5%) of γ quanta of electric quadrupole type in the $N^{*+} \rightarrow p + \gamma$ decay. Within the framework of SU(6) symmetry, the presence of such decay should lead directly to the existence of an electric quadrupole moment for baryons of the decuplet; the present article is devoted to an estimate of this moment.

We assume, as is customary, that the operator of the quadrupole moment of the baryons transforms with respect to the unitary SU(3) group like the corresponding component of an octet. This operator will therefore have, with respect to the subgroup $SU(2) \otimes SU(3)$ of the group SU(6), transformation properties of the type (5, 8). Then, from the point of view of the SU(6) group, this operator can belong to the 189-, 280-, 280*-, 405-plets, etc. The nonzero quadrupole transitions between baryons from the 56-plet can be obtained by assuming (as the simplest hypothesis) that the operator of the quadrupole moment belongs to the 405-plet:

$$Q_{A'B'}^{AB} \equiv Q_{i'\alpha', j'\beta'}^{i\alpha, j\beta} \approx [(\sigma\mathbf{e})_{i'}{}^{i}(\sigma\mathbf{q})_{j'}{}^{j} + (\sigma\mathbf{e})_{i'}{}^{j}(\sigma\mathbf{q})_{j'}{}^{i} + (\sigma\mathbf{e})_{j'}{}^{i}(\sigma\mathbf{q})_{i'}{}^{j} + (\sigma\mathbf{e})_{j'}{}^{j}(\sigma\mathbf{q})_{i'}{}^{i}](\delta_{\alpha'}{}^{\alpha}T_{\beta'}{}^{\beta} + \delta_{\alpha'}{}^{\beta}T_{\beta'}{}^{\alpha} + \delta_{\beta'}{}^{\alpha}T_{\alpha'}{}^{\beta} + \delta_{\beta'}{}^{\beta}T_{\alpha'}{}^{\alpha}), \quad (1)$$

where i, i′, j, j′ take on the values 1 and 2, the Greek indices run through the values 1, 2, and 3, **e** is the polarization vector of the γ quantum, **q** its momentum, and $T_{\alpha'}^{\alpha}$, the charge matrix.

Inasmuch as the product $\overline{56} \otimes 56$ contains the 405 multiplet once, the quadrupole moments of the baryons from the decuplet and the amplitudes of the quadrupole transitions are expressed in terms of one parameter. Using (1) we obtain for the electric quadrupole moments of the baryons from the decuplet the following structure:

$$\frac{eQ}{8}\bar{\chi}^{ijk}[(\sigma\mathbf{e})_{j}{}^{j'}(\sigma\mathbf{q})_{k}{}^{k'} + (\sigma\mathbf{e})_{k}{}^{k'}(\sigma\mathbf{q})_{j}{}^{j'}]\chi_{ijk}[2(\bar{N}^{*++}, N^{*++}) + (\bar{N}^{*+}, N^{*+}) + (\bar{Y}_1^{*+}, Y_1^{*+}) - (\bar{N}^{*-}, N^{*-}) - (\bar{Y}_1^{*-}, Y_1^{*-}) - (\bar{\Xi}^{*-}, \Xi^{*-}) - (\bar{\Omega}^{-}, \Omega^{-})], \quad (2)$$

where eQ coincides with the value of the quadrupole moments N^{*+} or Y_1^{*+}.

With the aid of (1) we obtain in terms of the same parameter Q the following expression for the amplitudes of the quadrupole radiative transition of the decuplet into an octet,

$$-\frac{eQ}{8\sqrt{6}}\bar{\nu}^{k'}\varepsilon^{ij'}[(\sigma\mathbf{e})_{j'}{}^{j}(\sigma\mathbf{q})_{k'}{}^{k} + (\sigma\mathbf{e})_{k'}{}^{j}(\sigma\mathbf{q})_{j'}{}^{k}] \times \chi_{ijk}\Big[(N^{*+} \rightarrow p\gamma) - (Y_1^{*+} \rightarrow \Sigma^{+}\gamma) + (N^{*0} \rightarrow n\gamma) - (\Xi^{*0} \rightarrow \Xi^{0}\gamma) + \Big(Y_1^{*0} \rightarrow \frac{\Sigma^0 - \sqrt{3}\Lambda}{2}\gamma\Big)\Big]. \quad (3)$$

Comparing (2) and (3) we obtain

$$Q(\Omega^-) = 8\sqrt{6}Q(N^{*+} \rightarrow p\gamma). \quad (4)$$

The quantity $Q(N^{*+} \rightarrow p\gamma)$ can be obtained by using the consequences of the isobar model.[1] The Hamiltonian describing the quadrupole transition in $N^{*+} \rightarrow p\gamma$ is of the form

$$H = em_\pi^{-2}c_4\bar{u}(p_2)\gamma_5 u_\nu(p_1)p_{1\mu}(e_\mu q_\nu - e_\nu q_\mu), \quad c_4 = 0.0043. \tag{5}$$

If we consider H in the nonrelativistic limits, we can separate from it a spin structure of the type (3) and thus express in terms of c_4 the amplitude of the $N^{*+} \rightarrow p + \gamma$ transition. Finally we obtain for the quadrupole moment of the Ω^- baryon the following estimate:

$$Q(\Omega^-) = -1.45e \cdot 10^{-26}\ \mathrm{cm}^2. \tag{6}$$

In conclusion it must be noted that experimental observation of the amplitude of the electric quadrupole absorption in the region of the first resonance is of great significance to the question considered above, that of the quadrupole moment of the baryons.

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[1] M. Gourdin and Ph. Salin, Nuovo Cimento **27**, 193 309 (1963). Ph. Salin, Nuovo Cimento **28**, 1294 (1963).

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