CAN WE OBSERVE THE $\frac{1}{2}^+$ CHARMED BARYONS C_1^{++}, C_1^+, C_1^0, X_u^{++} AND X_d^+?

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It has been discussed in this note that all the *observable* particles belonging to a given *baryonic* multiplet possess an important invariance property which demands that only fifteen out of the twenty $\frac{1}{2}^+$ baryons predicted by the SU(4) symmetry can occur in nature. This note claims that the $\frac{1}{2}^+$ charmed baryons C_1^{++}, C_1^+, C_1^0, X_u^{++} and X_d^+ do *not* exist in nature and as such these particles can *never* be observed. This claim is in conformity with the so far available experimental information on the $\frac{1}{2}^+$ charmed baryons.

It is well known that the SU(4) symmetry for the hadrons predicts [1] twenty $\frac{1}{2}^+$ baryons (of which twelve are charmed baryons) and sixteen 0^- mesons (which include one singlet meson). It may be recalled that the SU(4) scheme has already tasted some amount of success through the experimental detections [2, 3] of the 0^- charmed mesons D and F as well as their first excited states D* and F* respectively (in the notations of Ref. [1]). Unfortunately, however, the SU(4) scheme is not having a good going as far as the experimental detections of the $\frac{1}{2}^+$ charmed baryons are concerned. It may be mentioned here that the $\frac{1}{2}^+$ charmed antibaryon $\overline{C_0^+}$ was claimed to have been observed in the photoproduction [4] and the neutrino [5] experiments. Surprisingly enough, none of the twelve $\frac{1}{2}^+$ charmed baryons (or their antiparticles), predicted by the SU(4) symmetry, has been observed in the most recent e^+e^- annihilation experiments [6, 7] performed by the SLAC-LBL group. Our motivation in this note is to emphasize that the SU(4) scheme overestimates the number of the $\frac{1}{2}^+$ *charmed* baryons which can occur in nature. In this note we have discussed an important invariance property of the *observable* particles belonging to a given *baryonic* multiplet. This invariance property demands that out of twelve $\frac{1}{2}^+$ charmed baryons, predicted by the SU(4) symmetry, only seven such particles can occur in nature and the remaining five $\frac{1}{2}^+$ charmed baryons — C_1^{++}, C_1^+, C_1^0, X_u^{++}, X_d^+ — do not exist in nature and as such these five particles can *never* be observed. This fact has the implication that out of twenty $\frac{1}{2}^+$ baryons, predicted by the SU(4) scheme,

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only fifteen such particles are observable. The situation is indeed interesting if we remember that the SU(4) scheme admits [1] fifteen non-singlet 0^- mesons.

For our purpose mentioned above we shall employ invariance principle arguments. The necessity of the invariance properties of physical quantities is well known [8] and we have discussed this point elsewhere [9]. Alternatively, the invariant quantities are of physical interests. In this note we want to examine the possibility of finding out any invariant quantity which may be associated with the observable particles belonging to a given baryonic multiplet. For the convenience of discussions, we first consider the SU(3) multiplets of baryons. It is well known that neither isospin I nor strangeness S has the same value for all the particles belonging to a given SU(3) multiplet. It is highly interesting to note, however, that if we consider a linear combination of the SU(3) quantum numbers I and S in the form $|(2I+S)|$, then, it is found that the quantity $|(2I+S)|$ has the same value for all the members of a given SU(3) multiplet of baryons (and not mesons). The validity of this statement can be immediately checked by considering the particles belonging to the $\frac{1}{2}^+$ octet and the $\frac{3}{2}^+$ decouplet. In fact, the quantity $|(2I+S)|$ has the value unity for the nucleons ($I = \frac{1}{2}$, $S = 0$), Σ's ($I = 1$, $S = -1$), Λ($I = 0$, $S = -1$), Ξ's ($I = \frac{1}{2}$, $S = -2$) — all belonging to the $\frac{1}{2}^+$ octet. Also, it is easy to verify that the $|(2I+S)|$ has the same value (which is 3) for all the members of the $\frac{3}{2}^+$ decouplet. In this connection, it may be recalled that all the particles belonging to the $\frac{1}{2}^+$ octet and the $\frac{3}{2}^+$ decouplet have been experimentally detected. From this it is natural to conclude that for *all* the *observable* members of a given SU(3) multiplet of baryons the combination $|(2I+S)|$ has the same value and as such the quantity $|(2I+S)|$ behaves as an invariant. Needless to mention that the appropriate invariant for a given SU(3) multiplet of observable antibaryons is obviously $|(2I-S)|$ for well known reasons. For the sake of simplicity we have confined our discussions to the $\frac{1}{2}^+$ octet and the $\frac{3}{2}^+$ decouplet only but the above considerations are perfectly valid for the higher dimensional SU(3) multiplets of baryons.

The above considerations can now be extended to the *observable* particles belonging to the baryonic SU(4) multiplets. In fact, it is interesting to examine the consequences of demanding that the quantity $|(2I+S+C)|$, C denoting the charm quantum number, should behave as an invariant for the *observable* particles belonging to a given SU(4) multiplet of baryons. It is well known that the SU(4) multiplet of twenty $\frac{1}{2}^+$ baryons includes [1] the observed particles nucleons ($I = \frac{1}{2}$, $S = 0$, $C = 0$), Σ's ($I = 1$, $S = -1$, $C = 0$), Λ($I = 0$, $S = -1$, $C = 0$), Ξ's ($I = \frac{1}{2}$, $S = -2$) and for each one of these observed eight particles the quantity $|(2I+S+C)|$ has the value unity. We have already noted that the $\frac{1}{2}^+$ charmed anti-baryon $\overline{C_0^+}$($I = 0$, $S = 0$, $C = -1$) has been claimed [4, 5] to have been observed. Remembering that the appropriate invariant quantity for the observable particles belonging to a SU(4) multiplet of anti-baryons is $|(2I-S-C)|$, it is found that for the observed [4, 5] $\frac{1}{2}^+$ charmed anti-baryon $\overline{C_0^+}$ the quantity $|(2I-S-C)|$ has the desired value unity. Obviously, the observation of the $\overline{C_0^+}$ implies the same for the C_0^+ ($I = 0$, $S = 0$, $C = +1$) for which the quantity $|(2I+S+C)|$ has the value unity. All these facts offer a phenomenological justification to our demand that only those particles belonging to a given SU(4) multiplet of baryons will be observable for each one of which the quantity $|(2I+S+C)|$ has the same value. For the observable particles of the SU(4) multiplet of the $\frac{1}{2}^+$ baryons the quantity $|(2I+S+C)|$ must have the value unity. Needless to mention that for the observable particles of the SU(4) multiplet of $\frac{1}{2}^+$ anti-baryons the quantity $|(2I-S-C)|$ must also have the value unity. Using the SU(4) quantum numbers (I, S, C) for the $\frac{1}{2}^+$ baryons, given in Ref. [1], it can be easily checked that for only fifteen out of twenty $\frac{1}{2}^+$ baryons the quantity $|(2I+S+C)|$ has the desired value, namely, unity. It may be noted that for five $\frac{1}{2}^+$ charmed baryons — $C_1^{++,+,0}$ $(I = 1,\ S = 0,\ C = +1)$, $X_u^{++}(I = \frac{1}{2},\ S = 0,\ C = +2)$, $X_d^{+}(I = \frac{1}{2}, S = 0,\ C = +2)$ — the quantity does *not* have the value unity and as such these five particles are *not* observable. This claim receives an excellent support from the so far accumulated experimental information [4–6] on the $\frac{1}{2}^+$ charmed baryons.

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