The $\Delta(1232)^{++}$ baryon is OK

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The four $\Delta(1232)$ baryons

$$(\Delta^-,\ \Delta^0,\ \Delta^+,\ \Delta^{++}) \tag{1}$$

are members of the lightest isospin quartet of the Δ baryons. In an attempt to prove the need for QCD, particle physics textbooks state that the single particle wave functions of the quarks of the Δ^{++} baryon are symmetric ground state s-waves. Thus, the quantum numbers of the $\Delta(1232)^{++}$, $I = 3/2$ (a symmetric isospin) and $J^\pi = 3/2^+$ (a symmetric spin) demonstrate a fiasco of the Fermi-Dirac statistics of ordinary quantum mechanics (see e.g. [1], p. 5). The following short paragraph disproves this assertion.

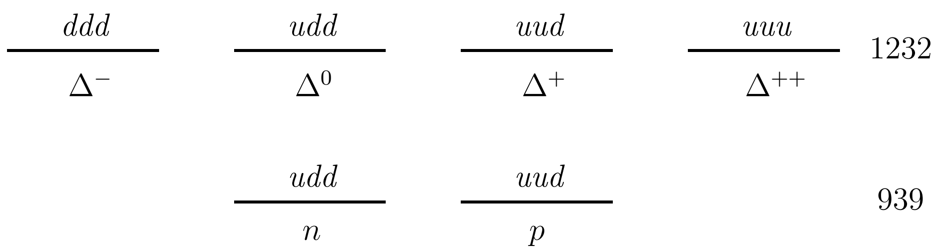

Fig. 1: Energy levels (in MeV) of members of two baryonic isospin multiplets. Valence quarks of each baryon are marked above its line.

Fig. 1 illustrates the energy values of the two I=1/2 nucleons and those of the four I=3/2 $\Delta(1232)$ baryons. The goodness of the isospin notion indicates that all the $\Delta(1232)$ baryons have the same space, spin and isospin symmetry. Hence, if the state of the Δ^{++} is inconsistent with fundamental laws of ordinary quantum mechanics then the same is true for the state of the Δ^0 and the Δ^+ baryons. However, it is clearly seen in fig. 1 that the Δ^0 and the Δ^+ baryons are *excited states* of the neutron and the proton, respectively. As excited states, the laws of ordinary quantum mechanics prove that the Δ^0 and the Δ^+ baryons should have excited space and spin states. This conclusion holds for every member of the isospin quartet (1). Hence, the single particle spatial part of the Δ^{++} quarks is *not* a ground state s-wave and its entire state is consistent with the laws of ordinary quantum mechanics.

An analogous argument holds for the **8** and the **10** representations of the SU(3) group, which include the corresponding baryons of fig. 1. For example, the spin-$3/2^+$ $\Sigma^+(1385)$ baryon of the **10** is an excited state of the spin-$1/2^+$ $\Sigma^+(1189)$ baryon of the **8**, etc. For this reason the ground state of the Ω^- baryon is also explained by the laws of ordinary quantum mechanics.

Conclusion: There is no need for the QCD construction.

For reading a relevant article, see [2].

References:

[1] F. Halzen and A. D. Martin, *Quarks and Leptons* (Wiley, New York, 1984). (See p. 5).

[2] E. Comay, Prog. in Phys., **4**, 55 (2011).