## CHARMED BARYONS

Figure 1 shows the SU(4) multiplets that have as their lowest levels (a) the SU(3) octet that contains the nucleon, and (b) the SU(3) decuplet that contains the $\Delta(1232)$. All the particles in a given SU(4) multiplet have the same spin and parity. The only known charmed baryons each contain one charmed quark and thus belong to the second level of an SU(4) multiplet. Figure 2 shows this level for the SU(4) multiplet of Fig. 1(a). The level splits apart into two SU(3) multiplets, a $\overline{\mathbf{3}}$ that contains the $\Lambda_c(2285)$ and the $\Xi_c(2470)$, both of which decay weakly, and a **6** that contains the $\Sigma_c(2455)$, which decays strongly to $\Lambda_c\pi$, and the $\Omega_c(2710)$, which decays weakly. A second $\Xi_c$ remains to be discovered to fill out the **6**, and a host of other baryons with one or more charmed quarks are needed to fill out the full SU(4) multiplets. Furthermore, *every* $N$ or $\Delta$ baryon resonance "starts" another SU(4) multiplet, so the woods are full of charmed baryons, most of which no doubt will forever remain undiscovered. The only candidates so far to belong to more massive multiplets are the $\Lambda_c(2593)$ and the $\Lambda_c(2625)$, and perhaps a $\Xi_c(2645)$; see the Listings.

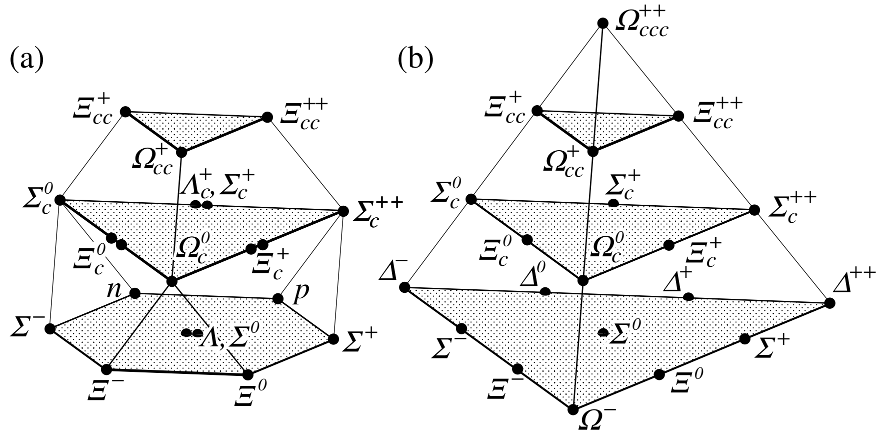


Fig. 1. SU(4) multiplets of baryons made of $u$, $d$, $s$, and $c$ quarks. (a) The 20-plet with an SU(3) octet on the lowest level. (b) The 20-plet with an SU(3) decuplet on the lowest level.

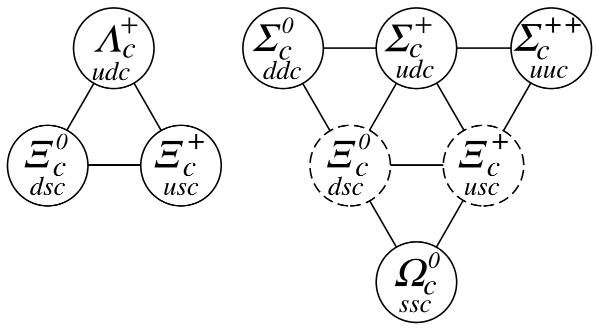


Fig. 2. The SU(3) multiplets on the second level of the SU(4) multiplet of Fig. 1(a). The particles in dashed circles have yet to be discovered.

The states of the $\overline{\mathbf{3}}$ multiplet in Fig. 2 are antisymmetric under interchange of the two light quarks (the $u$, $d$, and $s$ quarks), whereas the states of the **6** multiplet are symmetric under interchange of these quarks. Actually, there may be some mixing between the pure $\overline{\mathbf{3}}$ and **6** $\Xi_c$ states (they have the same $I, J$, and $P$ quantum numbers) to form the physical $\Xi_c$ states.

It need hardly be said that the flavor symmetries Fig. 1 displays are very badly broken, but the figure is the simplest way to see what charmed baryons should exist.

For a review of theory and experiment, see Ref. 1.

## References

1. J.G. Körner, M. Krämer, and D. Pirjol, Prog. in Part. Nucl. Phys. **33**, 787 (1994).