Comment on "Existence of Ξ Resonances above 2 GeV"

A recent study[1] of $K^-(p,X^-)K^+$ has confirmed all the three- and four-star states of Ξ in the Particle Data Group assignment,[2] as well as three out of seven states at $\lesssim 2.5$ GeV with one or two stars. Spin and parity determinations were not possible, and it is intriguing to make approximate assignments by extrapolation from observed states among the $Y=+1$ and $Y=0$ baryons. The assignments are based on conventional symmetries: viz., [SU(6), L^P] for supermultiplets and $^{2S+1}$SU(3) for component multiplets.

The main tool needed is a reliable value of dM^2/dY. This is known for at least the lowest $[\underline{56},0^+]$ supermultiplet: in the $^2\underline{8}$ multiplet the squared masses are 0.88, 1.29, and 1.74 GeV^2 as $Y=+1,\ 0,\ -1$; the corresponding values are $1.52\pm0.02,\ 1.92\pm0.05,\ 2.35\pm0.03$ GeV^2 in the $^4\underline{10}$ multiplet. This is perfectly consistent with a constant $dM^2/dY=-0.42\pm0.04$ GeV^2. The next higher state appears to be another $[\underline{56},0^+]$ comprising $N(1440)$, $\Lambda(1660)$, $\Sigma(1660)$ in $^2\underline{8}$ and $\Delta(1600)$, $\Sigma(1690)$ in $^4\underline{10}$. If we associate $\Xi(1680)$, $\Xi(1820)$ with these multiplets, we obtain $dM^2/dY=-0.39\pm0.07$ GeV^2. This is the same as the previous value within uncertainties and encourages the assumption of a constant dM^2/dY for $[\underline{56},0^+]$ supermultiplets.

In the next supermultiplet, $[\underline{70},1^-]$, the spin-orbit coupling causes variations in specific level positions, which are ignored by averaging all associated m^2 values with weight $(1J+1)$. Then the $^2\underline{8}$ multiplet comprises the $N(1535,1520)$, $\Lambda(1670,1690)$, $\Sigma(1620,1580)$ and yields $dM^2/dY=-0.42\pm0.11$ GeV^2. The $^4\underline{8}$ and $^2\underline{10}$ multiplets are essentially degenerate in the $Y=+1$ column, and their Σ members cannot be simply resolved; this degenerate grouping leads to $dM^2/dY=-0.42\ \pm0.18$ GeV^2. Although of reduced accuracy, these estimates are identical with those for $[\underline{56},0^+]$. Accordingly, we assume throughout a weighted average of $dM^2/dY=-0.42\pm0.05$ GeV.

It is important to recognize the limitations of the experiment.[1] The technique of displaying a resonance on top of a smooth background yields good results for isolated resonances, particularly with high spin; for a group with different spins and parities, however, interference effects can produce relatively sharp peaks and dips in the angular distributions of the detected particles. If some counters should be accidentally positioned near such a dip, the corresponding resonances would not appear very strong above background (which is itself incoherent and hence angularly smooth) and might be missed. This remark may apply to most of the $[\underline{70},1^-]$ supermultiplet states in the Ξ column which project to a band of resonances in the $\Xi(1940)$ region, not distinguished in Ref. 1. Note that there is a possible parity admixture in this region from a presumed $[\underline{70},0^+]\ ^2\underline{8}$ state represented by $N(1710)$, $\Lambda(1800)$, and $\Sigma(1880)$, and perhaps from the lowest members of the $[\underline{56},2^+]$ supermultiplet. The $\Xi(2030)$ seems to correspond best to an isolated member of this supermultiplet: probably $J^P=\frac{5}{2}^+$ corresponding to $\Sigma(1915)$ and presumably part of a $^2\underline{8}$ multiplet.

Another area of confused overlap appears to arise around $\Xi(2120)$, which encompasses the upper multiplet $^4\underline{10}$ of $[\underline{56},2^+]$ plus $^4\underline{10}$ levels of $[\underline{56},1^-]$ corresponding to $\Delta(1900,1940,1930)$ and $\Sigma(2000,1940,?)$; this region may also contain states from a $[\underline{70},2^+]\ ^4\underline{8}$ corresponding to $N(2100,?,2000,1940)$, $\Lambda(?,?,2110,2020)$, and unobserved Σ. Note that Fig. 3(b) shows a broad bump in the $\Xi(2120)$ region, which does not appear in Fig. 3(c), the output of a counter at a different c.m. angle.

The narrow states reported[1] above 2120 MeV appear to represent nearly isolated levels of high spin: $\Xi(2250)$, a $[\underline{70},3^+]$ state; the $\Xi(2370)$, some $[\underline{70},3^-]\ ^4\underline{8}$ and $[\underline{56},4^+]\ ^2\underline{8}$ state, the apparent yield being reduced by interference effects; $\Xi(2500)$ could be $[\underline{70},5^-]\ ^2\underline{10}$; and in Fig. 3(c) of Ref. 1, there is a peak at $\Xi(2570)$, which would be the right position for $[\underline{56},4^+]\ ^4\underline{10}$. Other members of these supermultiplets are known in $N,\Delta(2200-2400)$ and $\Lambda,\Sigma(2100-2500)$.

Of course these assignments become progressively more speculative with increasing mass. Their most likely hazard is that the constant dM^2/dY has a strong dependence on M^2, contrary to initial indications above. For this reason it would be desirable to attack one of the strong, narrow resonances at high mass in Ref. 1 to determine its exact J^P.

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[2] M. Roos *et al.*, Phys. Lett. 111B, 1 (1982).