ISOBAR MODEL ANALYSES OF STRANGENESS -1 BARYONS

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Two contributions from the Birmingham University group[1,2] describe isobar model analyses applied to data obtained from K^-d Bubble Chamber experiments with beam momenta 1.18, 1.33, 1.45, 1.65 and 1.78 GeV/c.

$\Lambda(1520) \to \Lambda\pi^+\pi^-$ Dalitz Plot Analysis

536 examples of this decay mode were selected by choosing events from the reaction $K^-d \to \Lambda\pi^+\pi^-\pi^- p_s$ with $\Lambda\pi^+\pi^-$ effective masses between 1.50 and 1.54 GeV/c^2. Each event was characterized by four parameters: the two Dalitz plot variables and the two angles describing the orientation of the proton from the Λ^o-hyperon decay. Maximum likelihood fits were made to the observed distributions using a generalized isobar model including interference effects. The formalism is similar to that used by previous experimenters.[5] Fits were made assuming that only isospin zero was important. The isobar amplitudes considered were those for $\Lambda\varepsilon$, $\Sigma(1385)\pi$, and $(\Lambda\pi)_{s\text{-wave}}\pi$ as well as phase-space. Combinations of amplitudes with spin-parities other than $^3/_2^-$ gave fits much poorer than those with $^3/_2^-$ and only the $^3/_2^-$ $\Sigma(1385)\pi$ s-wave and $^3/_2^-$ $\Lambda\varepsilon$ p-wave amplitudes were found to be required to fit the data. Unfortunately neither the $\pi\pi$ s-wave phase shifts in the mass region of interest($M_{\pi\pi} < 0.4$ GeV/c^2) nor the range of interaction used in the angular momentum barrier factors are well known. Alternative extreme choices of these parameters[5,6] lead to a wide variation of the $\Sigma(1385)\pi$ fraction as revealed in table I. An average of these results was taken giving 0.58 ± 0.22 for the ratio of $(\Lambda(1520)\to \Sigma(1385)\pi \to \Lambda\pi\pi)/$(all $\Lambda(1520) \to \Lambda\pi\pi$). The error was determined by examining the extent of the error ellipses on the Argand plot of the $\Lambda\varepsilon$ amplitude: these have very similar extents for the four fits shown. This ratio in turn leads to a value for $\Gamma[\Lambda(1520)\to \Sigma(1385)\pi]$ of 0.94 ± 0.38 MeV.

TABLE I

$\Lambda(1520) \to \Lambda\pi^+\pi^-$ Dalitz Plot Analysis

Parameterization	Range (fermis)	$\Sigma(1385)$ fraction*	$\Lambda\varepsilon$ fraction*	Interference fraction*	Log likelihood	Fit No.
Mast	1	$0.71^{+0.23}_{-0.17}$	$0.12^{+0.05}_{-0.01}$	$0.17^{+0.17}_{-0.27}$	771.6	1
Mast	0	$0.87^{+0.18}_{-0.52}$	$0.24^{+0.10}_{-0.07}$	$-0.11^{+0.53}_{-0.27}$	770.0	2
Scharenguivel	1	$0.45^{+0.24}_{-0.11}$	$0.16^{+0.05}_{-0.05}$	$0.39^{+0.06}_{-0.21}$	773.3	3
Scharenguivel	0	$0.28^{+0.22}_{-0.09}$	$0.29^{+0.09}_{-0.09}$	$0.43^{+0.02}_{-0.12}$	771.5	4

*The errors have been determined by searching for the lowest and highest values of the fractions within the contour of log likelihood 0.5 below the maximum.

To calculate the SU(3) singlet-octet mixing angle θ the formula $\tan^2\theta = 7.1\ \Gamma[\Lambda(1520)\to\Sigma(1385)\pi] / \Gamma[\Lambda(1690)\to\Sigma(1385)\pi]$ was used with $\Gamma(1690)$ taken to be 17 ± 8 MeV[7,8]. This gave $\theta = 31^\circ \pm 6^\circ$ compatible with $26^\circ \pm 3^\circ$ derived from d-wave decays of the $3/2^-$ baryons[3]. This analysis makes apparent the considerable sensitivity in the determination of θ to the choice of barrier factor due to the closeness of the $\Sigma(1385)$ to the edge of the allowed kinematic region and also to the form of the $\pi\pi$ s-wave phase shift.

Analysis of the reactions $K^-n \to K^-\pi^-p$ and $K^-n \to \bar{K}^0\pi^-n$ in the centre-of-mass energy range 1.9 to 2.2 GeV.

The same experiment has yielded 10,500 events fitting $K^-d \to K^-\pi^-pp_s$ and 8,000 events fitting $K^-d \to K^0\pi^-np_s$ (after weighting). Their Dalitz plots indicate that quasi two-body final states account for most if not all of these channels. Specifically the final states $\Lambda(1520)\pi$, $\Lambda(1815)\pi$, $\Delta(1236)\bar{K}$, $\bar{K}^*(890)N$, $N^*(1520)\bar{K}$ dominate. Relying on this dominance a generalized isobar model incorporating interference was used to fit the data from these channels. Maximum likelihood fits were made to the observed distribution in the four independent variables needed to describe final states produced from an unpolarized target. In view of the restricted number of events (only 1000 per channel per 30 MeV centre-of-mass energy bin) simple techniques were used to identify the most important amplitudes.
(1) The main contributions such as $\bar{K}^*N$ were roughly separated by mass selections and the observed production and decay angular distributions of the $\bar{K}^*$ compared with those expected for a given $\bar{K}^*N$ spin-parity.
(2) Fits were made to both channels simultaneously using the same pair of spin-parities (taken from $\frac{1}{2}^\pm, \ldots .. {}^9/_2{}^\pm$ in any combination) for the K^-n system. Likelihoods of the resulting fits were compared in order to distinguish important amplitudes. Both techniques indicated that the amplitudes which dominate have $J^P = {}^7/_2{}^+, {}^5/_2{}^-$ or ${}^3/_2{}^+$ with the choice of the lower orbital angular momentum between isobar and recoil. Energy independent fits were then made using just these spin-parities for the isobars listed earlier. Good fits are obtained to the data. Although fits of equal quality could probably be obtained with more complicated sets of amplitudes it seems reasonable to infer that the principal amplitudes and their quantitative importance have been correctly determined.

Figures 1 and 2 show the variation with centre-of-mass energy of the cross-sections for the various partial waves. In particular the ${}^7/_2{}^+$ $\Lambda(1815)\pi$ amplitude shows clear resonant structure around 2050 MeV. From the variation of these cross-sections with centre-of-mass energy it has been possible to obtain the following estimates of the $\Sigma(2030)$ branching fractions.

$\Lambda(1815)\pi$	$0.14 \pm .04$
$\Delta\bar{K}$	< 0.15
$\bar{K}^*N$	< 0.17
$\Lambda(1520)\pi$	< 0.03

The first two results are consistent with the estimates given by Litchfield and co-workers[9,10] at the Aix Conference. However the $\Lambda(1520)\pi$ branching fraction obtained here is much smaller than their value of $14 \pm 4\%$[4]. A low branching fraction is consistent with the assignments of $\Sigma(2030)$ to a decuplet and $\Lambda(1520)$ as mainly a singlet state in SU(3). If the branching fraction were as large as 14% then a similar magnitude $\Sigma(2030) \to \Lambda(1690)\pi$ decay mode ought to be present: this is certainly not seen.

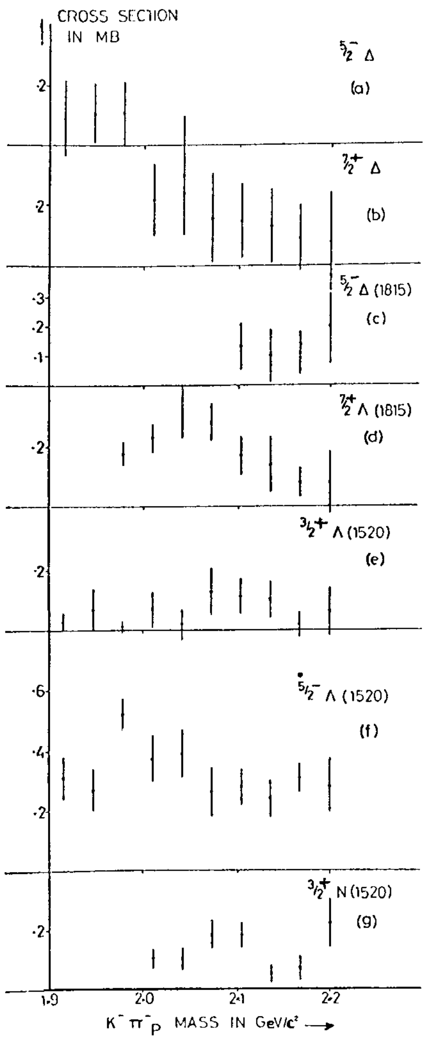

Fig.1. Partial wave cross-sections for the reaction $K^-n \to K^-\pi^-pp_s$ as a function of centre-of-mass energy.

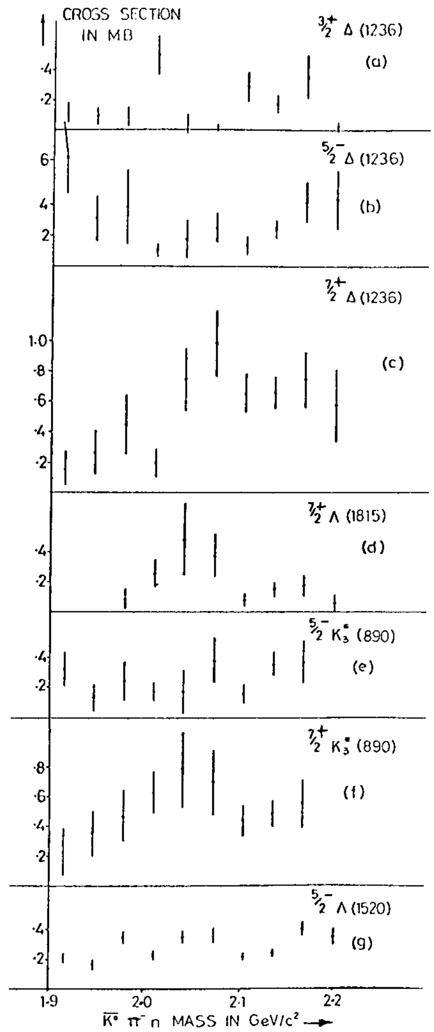

Fig.2. Partial wave cross-sections for the reaction $K^-n \to \bar{K}^0\pi^-np_s$ as a function of centre-of-mass energy.

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