tal cross sections in the s channel must necessarily have a_j nonzero at $t=0$.

[13] This difference between the elementary-particle-exchange result for F_P and the formal result of the partial-wave decomposition, Eq. (4), arises from the fact that the latter requires that the tensor currents at the vertices be conserved (the tensor operator for angular momentum j satisfies a set of divergence conditions $\partial_\beta T_{\alpha\cdots\beta\cdots}=0$). These conditions lead to the appearance in the partial-wave series of singular terms which may be associated with unphysical zero-mass particles in the singlet channel.

[14] Although the present argument is purely heuristic, it was shown in Ref. 2 to reproduce the results of Freedman and Wang for the scattering of particles of unequal mass. The existence of secondary trajectories in that case is also associated with the nonconserved character of the tensor currents.

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STRUCTURE IN THE K^--NUCLEON TOTAL CROSS SECTIONS BETWEEN 600 AND 1400 MeV/c

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The K^-p and K^-d total cross sections have been measured between 600 and 1400 MeV/c, at intervals of about 25 MeV/c, with a statistical accuracy typically of ±0.3 mb and with a momentum resolution of ±0.6%. In addition to the well-known resonances, a Y_0^* resonance with a mass of 1698 ± 5 MeV/c^2 is observed, and evidence is found for a $Y_1^*(1905)$, confirming an observation by Cool et al.[1]

The total cross sections have been measured by the conventional transmission technique using 55-cm-long targets of liquid hydrogen and deuterium. The targets, transmission counters, and electronics were similar to those used in a previous experiment on nucleon-nucleon total cross sections.[2]

Measurements were made in a 19-m unseparated beam, produced from an external target at Nimrod. The K^- meson flux ranged from 20 to 500 per 1.5×10^{11} extracted protons, while the total beam varied between 1.6×10^5 and 2.0×10^5. The K^- mesons were identified by a DISC[3] differential Cherenkov counter, using 5-cm thick liquid radiators and nine RCA 8575 photomultipliers in coincidence. The efficiency for K detection was over 90% and the rejection of unwanted particles was better than 2×10^{-6}. The beam contamination was thus insignificant at all momenta.

Accidental coincidences between particles in the beam were reduced to a negligible level by means of an electronic system[2] which vetoed, with efficiency better than 98%, any particle accompanied within the resolving time of the transmission counters by one or more others. Randoms arising from background particles not from the beam were also negligible.

Measurements at a given momentum consisted of several runs with each of the three targets (hydrogen, deuterium, and vacuum), and the runs were checked for consistency before averaging. Corrections made for additional decay, due to energy loss in the hydrogen and deuterium targets, varied between 4.0 mb at 600 MeV/c and 0.4 mb at 1400 MeV/c. Corrections were also made for Coulomb scattering, but no allowance has yet been made for Coulomb-nuclear interference. This correction will be small ($\lesssim$0.5 mb) and its principal effect is to decrease by 1 or 2 MeV/c^2 the apparent masses of all peaks in the total cross section.

Figures 1(a) and 1(b) show $\sigma(K^-p)$ and $\sigma(K^-d)$. For the sake of clarity, earlier results are omitted. Above 1 GeV/c, our results are in agreement with the recent accurate experiment of Cool et al.[1] At lower momenta the present

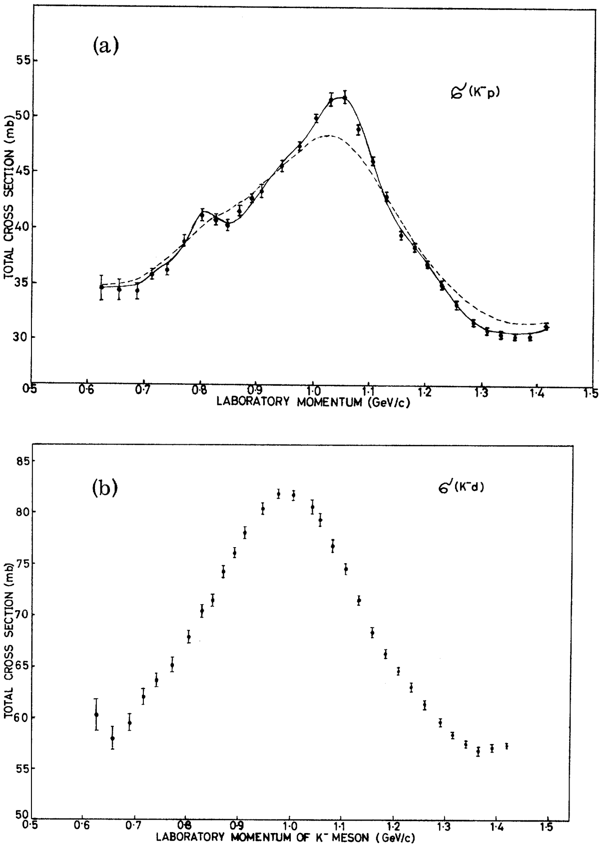

FIG. 1. (a) $\sigma(K^-p)$, (b) $\sigma(K^-d)$. The dotted curve in (a) shows "$\sigma(K^-p)$," obtained by folding in Fermi motion in the deuteron. The solid curve shows the best fit to the data using Breit-Wigner amplitudes for the resonances, superimposed on a smooth background (see text).

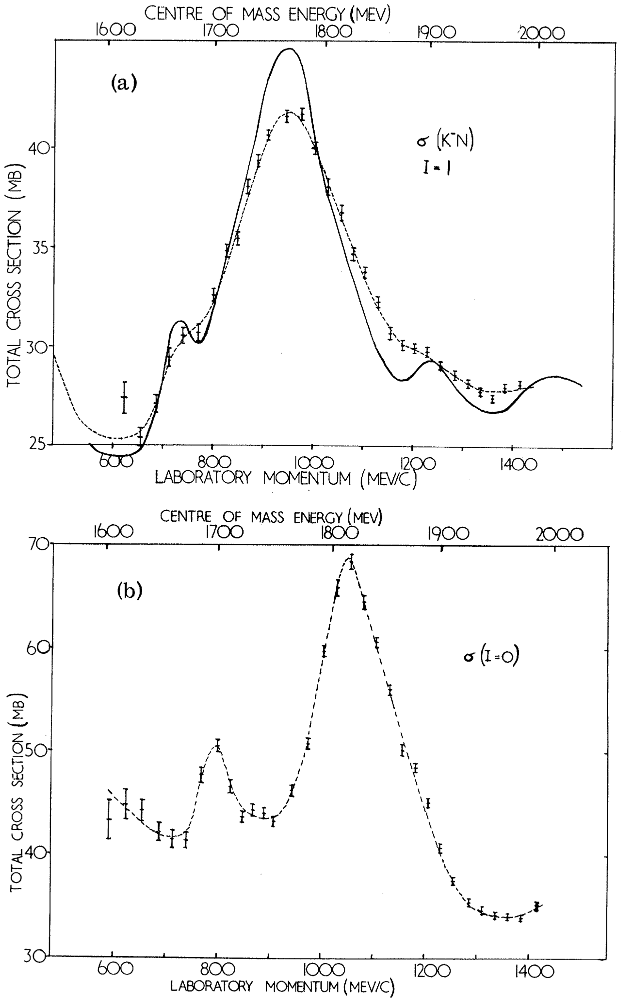

FIG. 2. (a) The experimental points are values of "$\sigma(K^-n)$," the K^-n cross section with Fermi motion folded in. The dotted curve is a smooth fit to these points. The solid curve is the result of unfolding the Fermi motion. Errors shown are purely statistical. (b) Values of $\sigma(I=0)=2\sigma(K^-p)-\sigma(K^-n)$, obtained from $\sigma(K^-p)$ and $\sigma(K^-n)$, the unfolded K^-n cross section. Errors shown are purely statistical.

results are consistent with the general trend of previous measurements.[4-6]

In $\sigma(K^-p)$, besides the well-known structure $[Y_0^*(1815)$ and $Y_1^*(1765)]$, there appears a pronounced shoulder at 800 MeV/c. It coincides with a rapid drop in the K^-n cross section and thus corresponds to a peak in $\sigma(I=0)$, as shown on Fig. 2(b). This is new Y_0^* resonance with a mass of 1698 ± 5 MeV/c^2 and a width of 40 ± 10 MeV/c^2. It seems quite distinct from the $\Lambda\eta$ resonance at a mass of 1661 MeV/c, which[7] appeared as only a 1 mb effect in the K^-p cross section. The best fit to a simple Breit-Wigner form for the $Y_0^*(1815)$ gives a mass of 1819 MeV/c^2 and a width of 90 MeV/c^2. At about 1200 MeV/c there is a distinct shoulder in $\sigma(K^-p)$ which will be identified below with a $Y_1^*(1905)$; this is probably the same structure as that reported by Cool *et al.*[1] at a mass of 1915 MeV/c^2.

In order to obtain the K^-n cross section, it is necessary to take account of both the screening effect and the Fermi motion in the deuteron. This calculation has been carried out as in Ref. 2 using a repulsive-core wave function for the deuteron. In the present work, the parameter $\langle r^{-2}\rangle$ used in the Glauber correction is taken to be 0.0423 mb^{-1}.[8] The result for "$\sigma(K^-p)$," the K^-p cross section as smeared out by the Fermi motion in the deuteron, is shown by the dotted line on Fig. 1(a). Subtracting this from $\sigma(K^-d)$ and applying the Glauber correction gives the values of "$\sigma(K^-n)$" shown by the experimental points in Fig. 2(a). At low momentum, a small but significant inflection marks the presence of the $Y_1^*(1660)$. Near 1200 MeV/c there is a shoulder in "$\sigma(K^-n)$" like that in $\sigma(K^-p)$ at about the same momentum. Although the positions of the shoulders in the two cross sections do not coincide exactly, it is likely that they can both be ascribed to the same effect, which is in the $I=1$ state.

In the center of our momentum range, "$\sigma(K^-n)$" shows a broad bump centered at a mass of 1770 MeV/c^2 and with a full width at half-height of about 120 MeV/c^2. A smooth curve [the dotted line of Fig. 2(a)] has been drawn through the experimental points and the Fermi motion unfolded with the result shown by the solid line. The result obtained is sensitive to the precise shape given to the dotted curve, but the outcome of the unfolding is always qualitatively the same, namely that three resonances are found at masses of 1662, 1775, and 1905 MeV/c^2 with widths of approximately 45, 120, and 60 MeV/c^2 respectively.

Breit-Wigner amplitudes superimposed upon a background which varies as $A+B/p$, where A and B are constants and p is the momentum, have been fitted to $\sigma(K^-n)$, to the unfolded K^-n cross section, and to $\sigma(I=0)$. Results from the experiment of Cool et al. were included in order to take into account the contributions in our momentum region from the tails of the $Y_1^*(2040)$ and $Y_0^*(2100)$ resonances. Widths used were 150 and 160 MeV/c^2, respectively. The results are shown in Table I.

Table I. Breit-Wigner amplitudes with constant widths have been used to obtain these resonance parameters. The resonant cross section is $\sigma_R = 4\pi\lambda^2(J+\frac{1}{2})x$ in a state of pure isospin, where J is the spin and $x = \Gamma_{\text{el}}/\Gamma$ is the elasticity of the resonance.

Isospin	Mass (MeV/c^2)	Width (MeV/c^2)	σ_R (mb)	$(J+\frac{1}{2})x$
1	1662 ± 5	45 ± 15	3.8	0.13
0	1698 ± 5	40 ± 10	12.3	0.49
1	1775 ± 5	120 ± 20	24.3	1.28
0	1819 ± 5	90 ± 15	36.7	2.21
1	1905 ± 5	60 ± 20	3.9	0.3

The $Y_0^*(1698)$ would appear to be a likely candidate to complete an SU(3) octet with the $N_{1/2}^*(1520)$, $Y_1^*(1660)$, and $\Xi_{1/2}^*(1816)$. These latter three particles, if fitted to the Gell-Mann–Okubo mass formula predict a Y_0^* mass of 1670 MeV/c^2. In the quark model,[9] one expects in addition to this $\frac{3}{2}^-$ octet, a second $\frac{3}{2}^-$ octet, and a $\frac{3}{2}^-$ singlet. It seems not unreasonable that mixing between them could shift the mass to 1698 MeV/c^2.

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