$K^{-}p \to K^{+}\Xi^{-}$ process in the two-meson-exchange peripheral model

1971 J. Phys. A: Gen. Phys. 4 L52

(http://iopscience.iop.org/0022-3689/4/3/005)

differential equation (7). A smaller step length would give the correct answer to four decimal places. However, in general a variable step length is preferable since, for example, at the distance $\bar{r}(\simeq 0{\cdot}5\ \mathrm{fm})$ when $f_{L,\mu_B}(\bar{r})$ is equal to $\pi/2$, the slope $\mathrm{d}f_{L,\mu_B}/\mathrm{d}r$ is about 82 fm^{-2} for the first eigenvalue. We see from table 1 and equation (6) that the differential equation (7) enables us to calculate quickly and accurately the energy eigenvalues of a given central potential.

One of us (P.E.N.) wishes to thank the SRC for the award of a Studentship.

Department of Applied Mathematics,
The University of Liverpool,
PO Box 147,
Liverpool, L69 3BX,
England.

M. W. Kermode
P. E. Nunn
15*th March* 1971

Abramowitz, M., and Stegun, I. A., Eds, 1965, *Handbook of Mathematical Functions* (New York: Dover Publications).
Calogero, F., 1967, *Variable phase approach to potential scattering* (New York: Academic Press).
Kermode, M. W., 1971, *J. Phys.* A: *Gen. Phys.*, **4,** L3–5.

$K^-p \to K^+\Xi^-$ process in the two-meson-exchange peripheral model

Abstract. The two-meson-exchange peripheral model has been used to explain the observed backward production features of the reaction $K^-p \to K^+\Xi^-$ in the intermediate energy region.

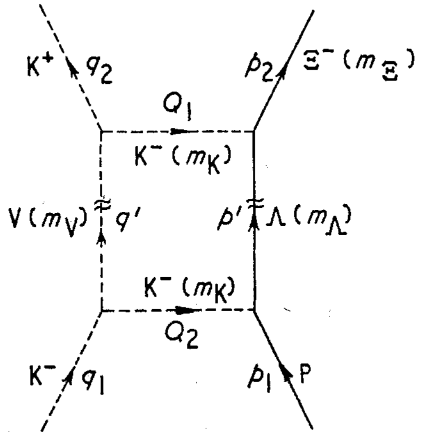
In the past, the data on peripheral processes have been explained by extending the argument first given by Chew and Low (1959). Following them, it has been assumed that when the singularity corresponding to the exchange of the lowest mass particle is not far from the physical region then, in the part of the physical region near the pole, the peripheral diagram is dominant. Usually, this means considering one-pion-exchange diagrams. Many workers (Chan and Liu 1965, Ebel and James 1967) have extended the meaning of the word 'peripheral' to assume that the one-particle-exchange (OPE) diagram, including the baryon-exchange diagrams, would dominate the scattering. This is the basis of the OPE model. The single-baryon-exchange calculation for the peripheral process

$$K^- + p \to K^+ + \Xi^- \tag{1}$$

showing backward (small u) peaking, gives differential cross sections which are orders of magnitude large and not sufficiently sharply peaked (Ebel and James 1967).

Ebel and James (1967) have applied the OPE model to the process (1) with absorption corrections. However, their prediction of the energy dependence of the total cross section is in violent disagreement with the data.

If we insist not on the exchange of a single particle but, in the Chew and Low philosophy, on the nearness of the singularity to the physical region of interest, it would be more meaningful to attempt a two-meson-exchange peripheral calculation. The purpose of this letter is to show that such a calculation for the process (1) gives results in quantitative agreement with data without introducing any adjustable parameters.



† Figure 1. Rescattering square diagram for the process (1).

We consider the two-meson-exchange box diagram shown in figure 1, where the momenta and masses are labelled. We assume that at the energies of interest ($\gtrsim$ 2 BeV/c) the absorptive part of the box diagram amplitude (Saxena *et al.* 1970a)

$$T^{\mathrm{abs}} = \frac{Y|q'|}{8\pi W}\bar{u}(p_2)\, g_{\bar{\mathrm{K}}\Lambda\Xi}\, \gamma_5(-\mathrm{i}\gamma.p'+m_\Lambda)\,\gamma_5\, g_{\bar{\mathrm{K}}\mathrm{p}\Lambda}$$
$$\times\, \mathrm{i}g_{\mathrm{VK\bar{K}}}(q_2-Q_2)_\nu\left(\delta_{\mu\nu}+\frac{q_\mu' q_\nu'}{m_{\mathrm{V}}^2}\right)$$
$$\times\, \mathrm{i}g_{\mathrm{VK\bar{K}}}(q_1+Q_1)_\mu\, u(p_1)$$

with

$$Y = \frac{1}{8|\boldsymbol{q}_1||\boldsymbol{q}'|^2|\boldsymbol{q}_2|}\frac{1}{(-\beta)^{1/2}}\ln\left(\frac{\alpha_1\alpha_2-\cos\theta+(-\beta)^{1/2}}{\alpha_1\alpha_2-\cos\theta-(-\beta)^{1/2}}\right)$$
$$\beta = 1-\cos^2\theta-\alpha_1^2-\alpha_2^2+2\alpha_1\alpha_2\cos\theta$$
$$\alpha_1 = \frac{2q_{10}q_0'-m_{\mathrm{V}}^2}{2|\boldsymbol{q}_1||\boldsymbol{q}'|}$$
$$\alpha_2 = \frac{2q_{20}q_0'-m_{\mathrm{V}}^2}{2|\boldsymbol{q}_2||\boldsymbol{q}'|}$$

corresponding to the two-step processes

$$\mathrm{K^-p}\rightarrow\left\{\begin{matrix}\rho & \Lambda\\ \omega & \Lambda\\ \phi & \Lambda\end{matrix}\right\}\rightarrow\Xi^-\mathrm{K}^+ \qquad (3)$$

† Replace Q_1 by Q_2 and vice versa.

gives the dominant contribution. The differential cross section can be calculated by adding incoherently the contributions from the three possible box diagrams and using the following values of the coupling constants:

$$\frac{g^2_{\bar{K}p\Lambda}}{4\pi} = 16{\cdot}2 \qquad \frac{g^2_{K\Lambda\Xi}}{4\pi} = 1{\cdot}8 \qquad \frac{g^2_{\rho K\bar{K}}}{4\pi} = 1{\cdot}2 \qquad \frac{g^2_{\Phi KK}}{4\pi} = 1{\cdot}5$$

$$\frac{g^2_{\omega K\bar{K}}}{4\pi} = 1{\cdot}0.$$

We have used Kim's (1968) values for $g_{Kp\Lambda}$. The corresponding value for $g_{\bar{K}p\Sigma}$ is smaller by a factor of about 50. Therefore we have left the box diagrams involving Σ in place of Λ.

The results of our calculations along with the recent data (Dauber *et al.* 1969) for the production angular distributions are shown in figure 2. We have obtained

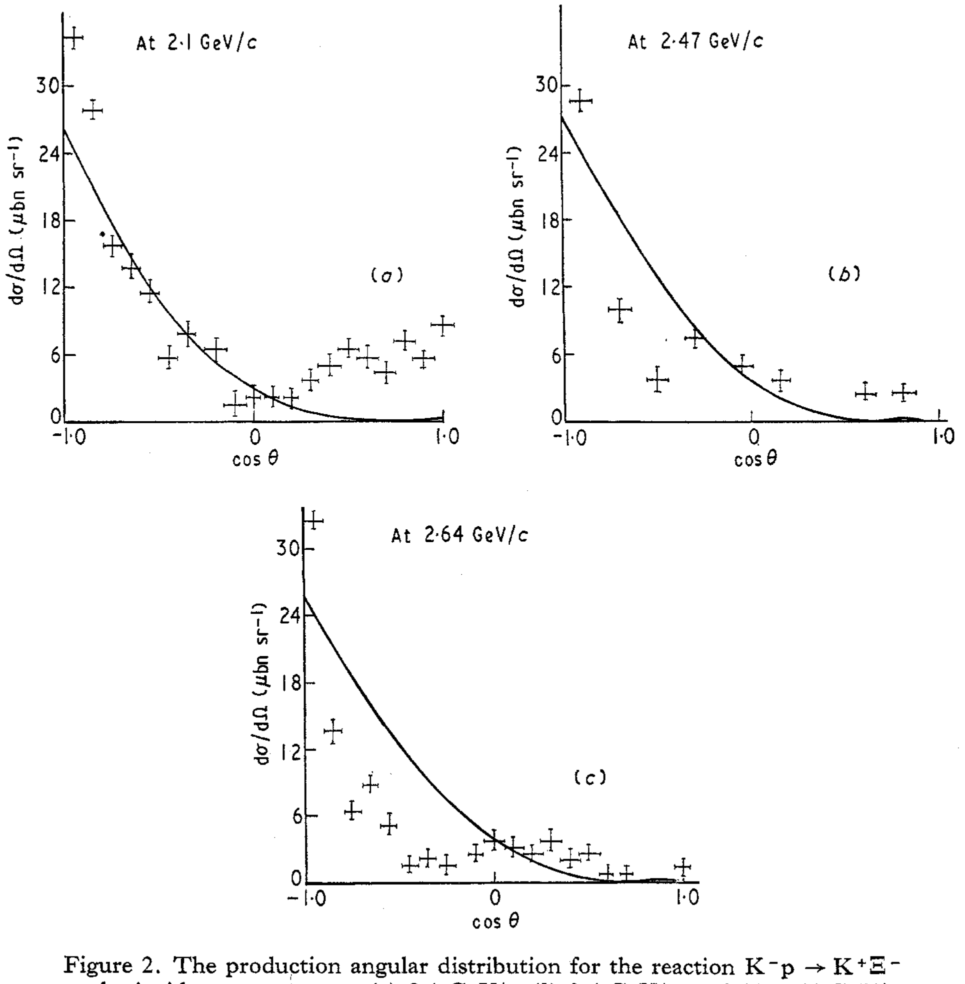


Figure 2. The production angular distribution for the reaction $K^-p \rightarrow K^+\Xi^-$ at the incident momentum: (*a*) 2·1 GeV/*c*, (*b*) 2·4 GeV/*c*, and (*c*) 2·64 GeV/*c*. Our theoretical curve has been shown by a full line and the experimental data are from Dauber *et al.* (1969).

the pronounced backward peaking of the K^+, which is the most striking feature of the $\Xi^- K^+$ production process (1). The predicted magnitude is of the right order without requiring any adjustable parameter. Moreover, we also obtain (figure 3) the

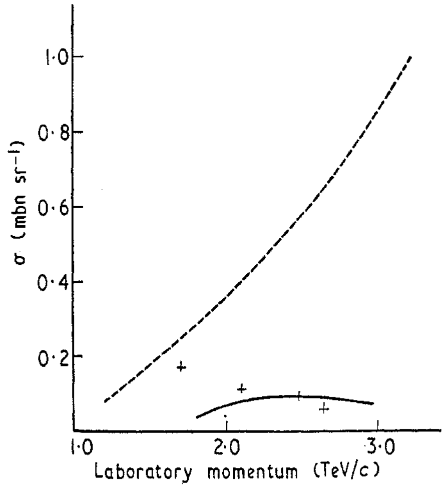


Figure 3. The total cross section for the reaction $K^- p \to K^+ \Xi^-$. The broken curve represents the calculation of Ebel and James (1967). The full line represents the result of our calculation.

energy dependence of the total cross section which is close to the observed data. In comparison, the OPE absorption model calculation gives a completely wrong energy dependence.

The two-meson-exchange peripheral calculation also gives a simple explanation for the backward peakings found in the processes $K^- p \to \Sigma^- \pi^+$ (Singh and Agarwal 1969) and $\pi^- p \to \Sigma^- K^+$ (Saxena *et al.* 1970b). The present calculation confirms that it is more appropriate to emphasize the nearness of the singularity to the physical region than the exchange of a single particle.

Two of us (C.P.S. and A.B.S.) are grateful to CSIR, New Delhi and one of us (K.J.N.) to State CSIR, Lucknow, for financial assistance.

Physics Department,
Allahabad University,
Allahabad,
India.

B. K. Agarwal
C. P. Singh
K. J. Narain
A. B. Saxena
17th March 1971

Chan, C. H., and Liu, Y. S., 1965, *Nuovo Cim.*, 298–307.
Chew, G. F., and Low, F. E., 1959, *Phys. Rev.*, **113,** 1640.
Dauber, P. M., *et al.*, 1969, *Phys. Rev.*, 1262–85.
Ebel, M. E., and James, P. B., 1967, *Phys. Rev.*, **153,** 1694–701.
Kim, J. K., 1968, *Phys. Rev. Lett.*, **19,** 1074–9.
Saxena, A. B., Agarwal, B. K., and Singh, C. P., 1970a, *J. Phys.* A: *Gen. Phys.*, **3,** 280–3.
Saxena, A. B., Singh, C. P., and Agarwal, B. K., 1970 b, *Phys. Rev.* D, **1,** 358–9.
Singh, C. P., and Agarwal, B. K., 1969, *Phys. Rev.*, **177,** 2350–2.