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[12]We have estimated β_L using an approximate steady-state relation,

$$\beta_L{}^2 \approx [\beta_e{}^2 + (\nu/\gamma)(1-f_e)] / (1 + (\nu/\gamma).$$

[13]L is the effective beam-chamber inductance per unit length.

[14]Current-probe data of Ref. 3 suggest a correlation between the time for attainment of $f_e \sim 1/\gamma^2$ and a dip in the net drift-chamber current.

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INTERACTION CROSS SECTION OF THE Q^- ENHANCEMENT

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(Received 19 August 1970)

We have observed coherent production of $K^-\pi^+\pi^-$ systems by K^- beams on nuclei and have measured the coherent production rate in the $Q(1300)$ region. Using the corresponding hydrogen and deuterium production rates we have calculated σ_{Q^-}, the Q^--nucleon total cross section. We find $\sigma_{Q^-} = 20.8_{-9.0}^{+7.2}$ mb at 10 GeV/c and $\sigma_{Q^-} = 20.8_{-8.4}^{+6.0}$ mb at 12.7 GeV/c.

Enhancements in the $(K\pi\pi)^\pm$ mass region near 1.3 GeV (Q region) have been reported by several groups observing interactions of high-energy $K^\pm$ beams on protons,[1] deuterons,[2] and heavier nuclei.[3] We report here an estimate of σ_Q, the Q^--nucleon total cross section. Our method consists in measuring the rate for coherent production of Q^- on nuclei. Then using a model which relates these results to Q^- production on protons and deuterons in terms of Q^--nucleon scattering, we deduce σ_{Q^-}. The magnitude of σ_{Q^-} may help to distinguish among models for the nature and production mechanism of the Q. Similar estimates of total cross sections have been reported for the A_1,[4] ρ,[5] ω,[6] and N_{1400}*.[7]

Experiment. —We have observed coherent production of $K\pi\pi$ final states by 5.5-, 10.0-, and 12.7-GeV/c K^- on nuclei. The 5.5- and 12.7-GeV/c exposures were made in the Brookhaven National Laboratory 80-in. bubble chamber filled with a neon-hydrogen mixture[8]; the 10-GeV/c exposure was made in the CERN 1.2-m heavy-liquid bubble chamber filled with a propane-freon mixture (composition ratio C:F:Br:H approximately 6:3:1:13). The film was scanned for three-prong events with no indication of nuclear breakup or of associated neutral particles detectable in the heavy liquid. The events were fitted to the reaction $K^-n \to K^-\pi^+\pi^-n$. The neutron mass was used for n in the fit because it is appropriate for high momentum transfer. For small momentum transfers where the mass of the nucleus might be used, the target mass does not make any significant difference in the results of the fit.

Most (90%) of the events gave two ambiguous fits corresponding to one or the other negative track being the K^-. A detailed analysis, based on Monte Carlo-generated events, allowed us to find, for each distribution studied, satisfactory fit selection criteria and corrections for the small residual distortions. The procedure was to generate a Monte Carlo set of events which approximated the data. They were put through kinematics which then gave the two ambiguous fits. Then selection criteria based on smallest momentum transfer and closest mass to 1260 MeV/c^2 were used on both the Monte Carlo and real events. The small distortion remaining in distributions and mass cuts was then corrected with the knowledge of which of the Monte Carlo fits was the correct one.

Momentum-transfer distribution. —Figure 1 shows the distribution of $t' = |t| - |t|_{\min}$, where t is the four-momentum transfer from target to recoil, and $|t|_{\min}$ the minimum value required to produce the particular system observed.

A fit with two exponentials for $t' < 0.3$ GeV/c gives, for the shallower slope, values compatible with the slopes found in diffraction production of $K\pi\pi$ systems in hydrogen,[9] as would be expected for incoherent nuclear production. The steeper slopes are in agreement with calculated values for coherent nuclear production when experimental resolution is taken into account. In the cross-

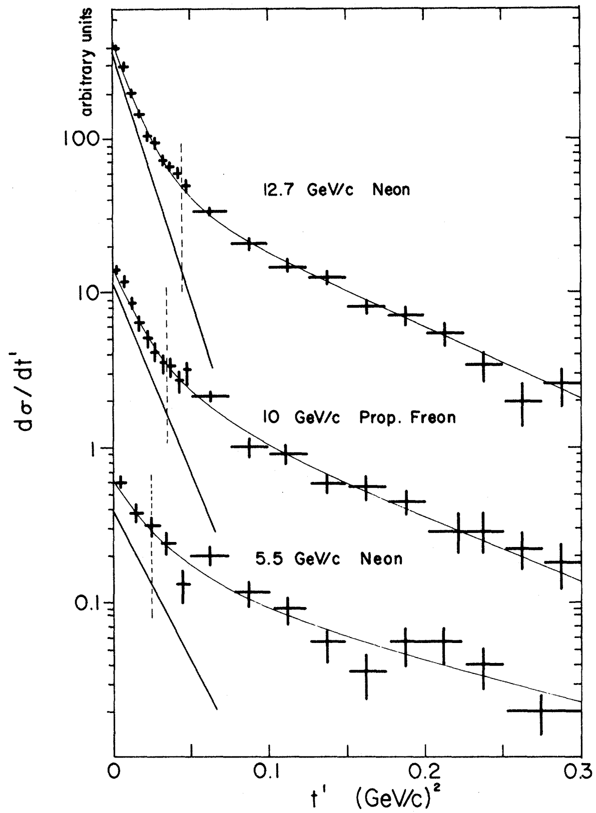

FIG. 1. Distribution of target-to-recoil momentum transfer, $t' = |t| - |t|_{\min}$, for the reaction K^- target $\to$ recoil $K^-\pi^+\pi^-$, 338, 958, and 2011 events with beam momenta 5.5, 10.0, and 12.7 GeV/c, respectively (no cuts). The curves show the results of two-exponential fits to the data, for $t' \leq 0.3$ GeV^2/c^2. The straight lines show the steeper exponential (coherent part). The dashed lines mark the t' cuts (t_0) used to obtain predominantly coherent event samples. The units in $d\sigma/dt'$ are arbitrary and only indicate relative values within each curve, not between curves.

section calculations that follow the total coherent production cross section is essentially independent of these slope values. The coherent $K\pi\pi$ production cross sections per nucleus deduced from these fits (by integrating under heavy solid lines in Fig. 1) are given in Table I.

Mass distributions. —For further analysis, we selected coherent events by requiring that t' be less than $t_0 = 0.025$ (GeV/c)^2 at 5.5 GeV/c, 0.035 (GeV/c)^2 at 10 GeV/c, and 0.045 (GeV/c)^2 at 12.7 GeV/c. Furthermore, since these events are dominated by $K_{890}^*\pi$ production, we have kept only those with $0.8 < M_{K^-\pi^+} < 1.0$ GeV. After these cuts the remaining samples contain 85% of coherent events and less than 5% of events where a K^0 or a π^0 has been missed.

Figure 2 shows the $K\pi\pi$ mass distributions for

Table I. Nuclear, H_2, and D_2 cross sections used to calculate $\sigma_Q = Q^-$-nucleon total cross section.

P (GeV/c)	σ_{coh}, all $K^-\pi^+\pi^-$ (mb)	σ_{coh}, Q region (mb)	σ_D, Q region (mb)	$\left(\frac{d\sigma}{dt'}\right)_{proton}^{t'=0}$ [mb/(GeV/c)^2]	σ_Q from H comparison (mb)	σ_Q from D comparison (mb)
5.5	1.68 ± 0.5	1.00 ± 0.26	0.140 ± 0.020			<52.0[a]
10	2.93 ± 0.33	1.93 ± 0.26		2.19 ± 0.17	$20.8^{+7.2}_{-9.0}$	
12.7	3.72 ± 0.26	2.47 ± 0.21	0.140 ± 0.035	2.12 ± 0.20	$20.8^{+6.0}_{-8.4}$	<32.0[a]

[a] At 90% confidence limit.

these events produced in nuclei in comparison with those reported from hydrogen and deuterium at the same energies.[9] To compare quantitatively the central masses and widths of the Q bumps produced under these varying conditions we have fitted to each mass distribution a Gaussian, weighted, for the D_2 and nucleus cases, by the nuclear form factor, and normalized in each case to the total number of events. The central masses and widths (full width at half-maximum) thus found were all compatible with 1.3 GeV and 290 MeV, respectively. The curves in Fig. 2 show the results of such fits with the central mass fixed at 1.3 GeV. The resulting widths are equal within 10 MeV and the curves are clearly good approximations to the data, although this parametrization oversimplifies what may be a complex structure. The Dalitz plots and decay angular distributions of the Q's produced under these various conditions are similar, as well. Thus we interpret these Q enhancements to be the same phenomenon and proceed to calculate its absorption cross section in nuclear matter by comparison of its hydrogen, deuterium, and nuclear production rates.

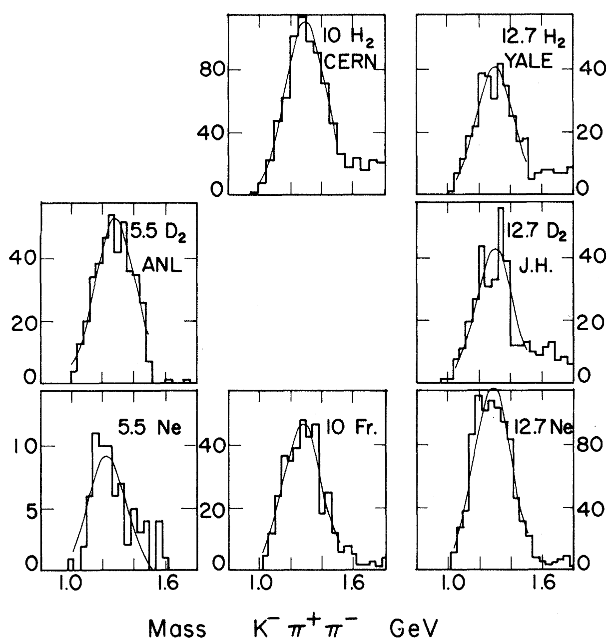

FIG. 2. $K^-\pi^+\pi^-$ mass distributions obtained with H_2, D_2, and nuclear targets at the three beam momenta. H_2 and D_2 data from Ref. 9; nuclear data from this experiment. The cut $0.8 < M_{K^-\pi^+} < 1.0$ GeV was required for all data, and $t < t_0$ (see text and Fig. 1) in addition for nuclear data. The curves show the results of fits to the data, for $1.0 < M_{K\pi\pi} < 1.5$ GeV, of a Gaussian mass distribution with the central mass = 1.3 GeV and the width free, and weighted, for D_2 and nuclei, by the nuclear form factor. The resulting fitted widths were all compatible with 290 MeV (full width of half maximum).

Q interaction cross section.—In order to estimate σ_Q we have used the model of interactions in nuclei developed by Formanek and Trefil[10] on the basis of Glauber theory. It relates the coherent production cross section of the Q on a nucleus to its forward production cross section on a nucleon:

$$\sigma_{coh} = (d\sigma/dt')_{nucleon}^{t'=0} G(\sigma_Q). \qquad (1)$$

The quantities appearing in Eq. (1) are as follows:

$(d\sigma/dt')_{nucleon}^{t'=0}$ is the squared modulus of the scalar-isoscalar exchange part of the forward amplitude of $K^-N \to Q^-N$. This quantity is not directly available from experiment; hence we have used instead $(d\sigma/dt')_{proton}^{t'=0}$. In fact, we expect this to be a good approximation for diffractive processes. See Ref. 3 for further discussion.

$G(\sigma_Q)$ contains the effects of nuclear absorption and of the coherent interference between the outgoing waves from different parts of the nucleus. It takes the form of an integral over t' with contributions from the following: (a) The nuclear shape. A Woods-Saxon distribution is used, with parameters derived from Alvensleben et al.[11] (b) The slope[12] and phase[13] of K^-N elastic scattering. (c) The K^-N total cross section[14]. (d) The unknown Q^-N total cross section. The explicit form of $G(\sigma_Q)$ is given in footnote 11 of Ref. 3.

In our data the coherent cross section has been determined for the sample $M_{K\pi\pi} < 1.5$ GeV and $0.8 < M_{K^-\pi^+} < 1.0$ GeV from a two-exponential fit to the t' distribution with a small correction for the nonexponential behavior of the incoherent part near $t' = 0$.[15] Using the existing data at the same energies on hydrogen and deuterium and making the same cuts, we find for σ_Q the values in Table I. The errors quoted for σ_Q and R below take into account the uncertainties in the nuclear parameters. Comparing the 10- and 12.7-GeV/c results with σ_{K^-}, the average of the K^-p and K^-n total cross sections at the same energy,[14] and taking a weighted mean of the ratios we obtain

$$R \equiv \sigma_{Q^-}/\sigma_{K^-} = 0.98^{+0.24}_{-0.37}.$$

Discussion.—The Q^--nucleon total cross section, measured here in the $K^{*0}\pi^-$ mode, is new information on the $K^*\pi$ system in the Q region. The deduction of σ_{Q^-} from our data required no dynamical assumptions about the Q, and is in this sense model independent. Even if the Q cannot be considered a single particle, σ_{Q^-} still has the significance of a nuclear absorption parameter for the outgoing $K^*\pi$ state, averaged over the mass region $M_{K^*\pi} < 1.5$ GeV/c.

In principle, σ_{Q^-} can be predicted from dynamical models. For example, if the K^* and π were completely uncorrelated, and if $\sigma_{K^{*0}} \geq \sigma_{K^-}$, one would expect $R \gtrsim 2$[4,11] in disagreement with our measurement. On the other hand, a number of higher symmetry models[16] imply $R = 1$, on the assumption that the Q is a single resonance. This prediction is clearly in good agreement with our measurement.

It is a pleasure to thank the 80-in. bubble chamber personnel for their successful operation of the chamber using a Ne-H_2 mixture. The encouragement and counsel of Professor A. Lagarrigue is much appreciated as well as information obtained from D. Denegri, D. R. O. Morrison, T. Ludlam, and B. Musgrave. We thank W. R. Graves, J. F. Grivaz, and J. Pipkin for their contributions to various aspects of the experiment.

*Work supported by the U. S. Atomic Energy Commission.

†Work supported in part by the National Science Foundation.

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