CERN/EP 79-72 Rev.
4 July 1979
(Rev. on 17.9.1979)

OBSERVATION OF THE REACTION $K^- p \rightarrow B^- Y^{*+}$ AT 8.25 GeV/c

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ABSTRACT

Forward production of B^- is observed for the first time in the reaction $K^- p \rightarrow B^- Y^{*+}$ (1385), where the B^- production is characterized by $\rho_{00}^t \sim 1$, consistent with the dominance of natural parity (K^*) exchange.

Submitted to Physics Letters B

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- (*) Supported by the Science Research Council, U.K.
(**) Supported by the National Science Foundation, USA.
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CM-P00068142

In this paper we report on some properties of B^- meson production in K^-p interactions at 8.25 GeV/c. It has been pointed out [1] that the B , as well as coupling to the $\pi\omega$ channel, should have, on the basis of SU_3 , comparable coupling to the virtual KK^* channel. As a result, B production in K^-p reactions might be expected to occur predominantly by K^* exchange, as has indeed been observed [1].

Here we present the first data on the quasi two-body channel

$$K^-p \rightarrow B^- Y^{*+}(1385) \quad (1)$$

obtained from the reaction

$$K^-p \rightarrow \pi^+ \pi^+ \pi^- \pi^- \pi^0 \Lambda^0. \quad (2)$$

Additional B^- production in channel (2) and in the reaction

$$K^-p \rightarrow \pi^+ \pi^- \pi^- \pi^0 \bar{K}^0 p \quad (3)$$

is briefly noted.

The data come from the analysis of about half of a 5.10^6 picture exposure of the CERN 2m HBC to a RF separated beam of 8.25 GeV/c K^- mesons. The current sensitivity of the experiment is ~ 100 events/ μb .

The sample of events for the channel

$$K^-p \rightarrow \pi^- \omega^0 Y^{*+}(1385), \quad (4)$$

has been obtained from the events of reaction (2) by selecting $1.34 < M(\Lambda\pi^+) < 1.42$ GeV with one of the recoiling $M(\pi^+\pi^-\pi^0)$ combinations in the mass range 0.745 - 0.82 GeV. The number of cases in which both $M(\Lambda\pi^+)$ combinations lie in the Y^* region is negligible, while in $\sim 5\%$ of the cases both $M(\pi^+\pi^-\pi^0)$ values lie in the ω^0 region. By comparing the number of events in the ω^0 peak when the $Y^*(1385)$ region is selected with the result of selecting Y^{*+} side-bands, we determine the channel (4) contains 270 ± 30 events. Observation of the Y^{*+} signal when ω^0 region

or ω^0 side-bands are selected gives a result consistent with the above. These tests indicate that the sample obtained for reaction (4) by these cuts contains $\sim 45\%$ background. After correction for unseen decay modes we obtain

$$\sigma(K^- p \rightarrow \pi^- \omega^0 Y^{*+}) = 6.75 \pm 1.00 \text{ } \mu\text{b}$$

$$(4.35 \pm 0.65 \text{ } \mu\text{b for } t(Y^*) < 2.0 \text{ GeV}^2).$$

Fig. 1(a) shows the $M(\pi^- \omega)$ spectrum for the event sample of channel (4) after imposing a momentum transfer cut, $|t(Y^*)| < 2.0 \text{ GeV}^2$. A clear B^- signal is seen. In channel (4) essentially all events in the B^- mass region are found at $|t| < 2.0 \text{ GeV}^2$. For the few events in the backward region ($|t| > 9 \text{ GeV}^2$) no significant B^- signal is observed.

The mass spectrum obtained by selection of the ω^0 side-bands instead of the ω^0 region shows no peak, indicating that the peak observed in fig. 1(a) is due to the $\pi^- \omega^0$ state. Similar procedures using several $M(\Lambda \pi^+)$ regions confirm the B^- signal to be associated with $Y^{*+}(1385)$. The curves in fig. 1(a) show the result of a fit to the mass spectrum and give the results

$$M = 1.234 \pm 0.015 \text{ GeV} \quad \Gamma = 0.150 \pm .050 \text{ GeV}.$$

These results are consistent with accepted values [2].

Before examining further the properties of the $B^- Y^{*+}$ final state, we turn briefly to the reaction

$$K^- p \rightarrow B^+ Y^{*-}(1385). \quad (5)$$

By similar methods as used to obtain the sample for reaction (4), we select events for reaction (5). The resulting $\pi^+ \omega^0$ effective mass spectrum is shown in fig. 1(b) where the backward hemisphere has been selected. Possible evidence for backward production of B^+ is seen. All the events in the

B^+ mass region have $|u'| < 2.0 \text{ GeV}^2$. Thus, we have evidence for $B^- Y^{*+}(1385)$ production and an indication of $B^+ Y^{*-}$ production. The cross sections for these channels are

$$\sigma(K^- p \rightarrow B^- Y^{*+}(1385)) = 2.00 \pm 0.40 \text{ } \mu\text{b} \quad (|t| < 2.0 \text{ GeV}^2)$$

$$\sigma(K^- p \rightarrow B^+ Y^{*-}(1385)) = 0.40 \pm 0.25 \text{ } \mu\text{b} \quad (|u| < 2.0 \text{ GeV}^2).$$

We obtain

$$\sigma(K^- p \rightarrow \pi^+ \omega^0 Y^{*-}) = 3.80 \pm 0.75 \text{ } \mu\text{b}$$

$$(1.90 \pm 0.45 \text{ } \mu\text{b} \text{ for } t(Y^*) > 5.0 \text{ GeV}^2).$$

Now we return to examine further the characteristics of the reaction

$$K^- p \rightarrow B^- Y^{*+}(1385). \quad (6)$$

We display in fig. 2 the decay distributions for B^- and Y^{*+} . We have chosen to present the B^- decay angular distributions in the t -channel (Gottfried-Jackson) frame and the Y^{*+} distribution in the transversity frame. The angular distributions have been obtained using data from the region $1.08 < M(\pi^- \omega) < 1.40 \text{ GeV}$ with a background subtraction. The background distributions have been taken from the region $1.44 < M(\pi^- \omega) < 1.84 \text{ GeV}$. In cases where the background is consistent with being flat, a uniform background has been subtracted from the signal region, in other cases the observed background distributions has been subtracted. In each of the presented angular distributions the histogram shows the background subtracted data over the whole angular region. Since these distributions appear symmetric, we use the folded distributions, shown by points with error bars, to compare the data with the symmetric distributions of eqs 7 to 10 and 12 given below.

The decay of the B-meson is described by four angles, the distributions for which are shown in figs 2(a) to 2(d). The angular distribution for the B to $\pi\omega$ decay is defined by the direction of the ω in the B rest frame, using as z-axis the incident K^- direction in this frame and as y-axis the normal to the production plane. This decay distribution is then described by the polar and azimuthal angles θ and ϕ . The subsequent ω to $\pi^+\pi^-\pi^0$ decay angular distribution is defined in the ω rest frame by the direction of the normal to the 3-pion decay plane relative to the axes, Z' chosen along the line-of-flight of the ω in the B rest frame, and Y' chosen in the direction $Z \times Z'$. The ω decay distribution is then described by the polar and azimuthal angles χ and ψ respectively.

These four angular distributions have the form [3]

$$W(\cos\theta) = \frac{3}{2} \left[(\rho_{11} \sin^2\theta + \rho_{00} \cos^2\theta) |F_0|^2 + (\rho_{11}(1 + \cos^2\theta) + \rho_{00} \sin^2\theta) |F_1|^2 \right] \quad (7)$$

$$W(\phi) = \frac{1}{2\pi} \left[1 - \rho_{1-1} (3|F_0|^2 - 1) \cos^2\phi \right] \quad (8)$$

$$W(\cos\chi) = \frac{3}{2} \left[|F_1|^2 \sin^2\chi + |F_0|^2 \cos^2\chi \right] \quad (9)$$

$$W(\psi) = \frac{1}{2\pi} \left[1 + (3\rho_{00} - 1) |F_1|^2 \cos^2\psi \right] \quad (10)$$

From eq. (9) it is clear that $|F_\lambda|^2$ represents the probability for finding the ω with helicity λ . The normalisation is $2|F_1|^2 + |F_0|^2 = 1$ ($|F_1|^2 = |F_{-1}|^2$ by parity conservation). Using the known d/s amplitude ratio, 0.29 ± 0.05 for B to $\pi\omega$ decay [2] the value of $|F_0|^2 = 0.11 \pm .03$ is determined [3]. In the following we use $|F_0|^2 = 0.1$. Eq. (9) shows the $\cos\chi$ distribution to be independent of the B production mechanism. In fig. 2(c) the prediction obtained using $|F_0|^2 = 0.1$ is shown by the dashed curve and shows reasonable agreement with the data. The solid curve shows the result of a fit which gives the result $|F_0|^2 = 0.22 \pm 0.11$ consistent with the result expected for B-meson decay. For the remaining three distributions the curves show the expected behaviour for production of B with $\rho_{00} = 1$. Clearly the agreement between the shown curves and

the data is very good. A uniform distribution in ψ (fig. 2(d)) is excluded at the 3σ level. Since information on the value of ρ_{00} is obtained only from the distributions $\cos\theta$ (fig. 2(a)) and ψ (fig. 2(d)), we have determined the best value of ρ_{00} from the combined $\cos\theta, \psi$ distribution, by a maximum likelihood fit, using

$$W(\cos\theta, \psi) = \frac{3}{4\pi} \left[|F_0|^2 (\rho_{11} \sin^2\theta + \rho_{00} \cos^2\theta) + |F_1|^2 \left\{ \rho_{11}(1 + \cos^2\theta) + \rho_{00} \sin^2\theta + (\rho_{00} - \rho_{11}) \sin^2\theta \cos 2\psi \right\} \right] \quad (11)$$

with $|F_0|^2$ fixed at 0.1. The results obtained for ρ_{00} are shown in table 1. For production of a resonance with unnatural spin parity the part of the cross section giving rise to the ρ_{00} component is produced by natural parity exchange alone [4]. Thus, our observations are consistent with the expectation of an important contribution to B production by K^* exchange. Fig. 2(e)) shows the decay distribution of the $Y^{*+}(1385)$ with respect to the normal to the production plane. The curve shows the result of a fit to a distribution of the form

$$W(\cos\theta) \approx 1 + A \cos^2\theta \quad (12)$$

which gives the result, $A = 2.3 \pm 1.7$. It is perhaps worth noting that this value is consistent with the value $A = 3.0$ which is found in some reactions for $Y^*(\Delta)$ production by $K^*(\rho)$ exchange as predicted by Stodolsky and Sakurai [5].

Fig. 3 shows the background subtracted t' distribution obtained using the same signal and background regions as for the angular distributions of fig. 2. For the region $0.2 < |t'| < 2.0 \text{ GeV}^2$ the distribution has been fitted to an exponential and a value of $b = 2.8 \pm 1.1 \text{ GeV}^{-2}$ obtained for the slope parameter. There is some evidence of a forward dip in $d\sigma/dt$ for $|t'| < 0.1 \text{ GeV}^2$.

Finally, we note that B^- production also occurs in channel (2) when $Y^{*+}(1385)$ is not produced, and also in channel (3). From fits to the mass spectra we obtain

$$\begin{aligned}\sigma(K^- p \rightarrow B^- \pi^+ \Lambda) &= 3.85 \pm 1.00 \text{ } \mu\text{b} \\ |t'| &< 2 \text{ GeV}^2, \\ \sigma(K^- p \rightarrow B^- \bar{K}^0 p) &= 6.4 \pm 1.6 \text{ } \mu\text{b}\end{aligned}$$

where the first figure given does not include the quasi 2-body channel (1).

In channel (2) we have also observed the backward production of both B^+ and B^- which have been shown to arise mainly from the decay of $\omega(1670)$ [6].

In conclusion, we have shown the existence of the channel

$$K^- p \rightarrow B^- Y^{*+}(1385)$$

at 8.25 GeV/c with a cross section of $2.00 \pm 0.40 \text{ } \mu\text{b}$ for $|t| < 2.0 \text{ GeV}^2$. The decay distributions of the B^- show the production mechanism to involve mainly natural parity exchange. This is consistent with the expectation that K^* exchange should play an important role, as has been observed in B^- production in other $K^- p$ reactions [1]. The reaction (1) was not observed in an experiment at 4.2 GeV [1] where an upper limit for the cross section of $2 \text{ } \mu\text{b}$ was quoted. It should perhaps be pointed out, that at lower energies the observation of reaction (1) is made more difficult by the limited extent of phase-space.

Acknowledgement

We wish to acknowledge the help of the operating crews of the CERN PS and the 2m HBC and the constructors of the RF beam. We also thank the scanning, measuring and computing staffs at each of our laboratories.

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to Physics Letters.

TABLE 1

Determination of ρ_{00} for B production in $K^- p \rightarrow B^- Y^{*+}$

Range of $ t' $ (GeV ²)	Value of ρ_{00}
0.0 - 1.0	0.85 ± 0.12
0.0 - 0.3	1.00 ± 0.17
0.3 - 1.0	0.68 ± 0.20

FIGURE CAPTIONS

- Fig. 1 (a) The $M(\pi^-\omega)$ distribution from $K^-\bar{p} \rightarrow \pi^-\omega Y^{*+}(1385)$ for $|t(Y^*)| < 2 \text{ GeV}^2$.
- (b) The $M(\pi^+\omega)$ distribution from $K^-\bar{p} \rightarrow \pi^+\omega Y^{*-}(1385)$ for $|t(Y^*)| > 5 \text{ GeV}^2$.
- Fig. 2 (a)-(d) The angular distributions for the decay of B^- from reaction (1) for the Gottfried-Jackson frame. See text for definitions.
- (e) The angular distribution for the decay of $Y^{*+}(1385)$ from reaction (1) for the transversity frame.
- Fig. 3 The $|t'|$ distribution for reaction (1). The curve shows the result of a fit to an exponential distribution.

Fig. 1

Fig. 2

Fig. 3