Lawrence Berkeley National Laboratory
Recent Work

Title
ANTIXI PRODUCTION IN K p INTERACTIONS AT 9 BeV/c

Permalink
https://escholarship.org/uc/item/0m74g044

Authors
Shen, Benjamin C.
Firestone, Alexander
Goldhaber, Gerson.

Publication Date
1967-08-09
ANTIXI PRODUCTION IN K⁺p INTERACTIONS AT 9 BeV/c
Benjamin C. Shen, Alexander Firestone, and Gerson Goldhaber
August 9, 1967
DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.
ANTIXI PRODUCTION IN \( K^+ p \) INTERACTIONS AT 9 BeV/c

Benjamin C. Shen, Alexander Firestone, and Gerson Goldhaber

August 9, 1967
ANTIXI PRODUCTION IN K⁺p INTERACTIONS AT 9 BeV/c

Benjamin C. Shen,* Alexander Firestone, and Gerson Goldhaber
Dept. of Physics and Lawrence Radiation Laboratory
University of California, Berkeley California

August 9, 1967

We have observed charged antixi production in K⁺p
interactions at 9 BeV/c with σ = 5.3 µb. Nothing observed
indicates that these antixi hyperons are decay products of
an intermediate resonance. We have found no event consistent
with antiomega production.

Production of antihyperons has until now been studied mainly in inter-
actions of antiprotons with protons. However, availability of high-
energy secondary meson beams makes the study of antihyperon production
energetically possible in meson-nucleon experiments. In the interactions
of K⁺ mesons with protons we have observed evidence for antibaryon and anti-
hyperon production. We present results of a search for antihyperons of
strangeness equal to or greater than two, namely antixi and antiomega. All
together twelve events found have been clearly identified by kinematics
and ionization as involving antixi production; and no events were found
involving antiomega production.

The Brookhaven National Laboratory 80-inch hydrogen bubble chamber was
exposed to a rf-separated K⁺ meson beam at 9 BeV/c incident momentum at the
Alternating Gradient Synchrotron$^{10)}$. A total of 100,000 stereo photographs was taken with the Berkeley camera system$^{11)}$. The film was scanned for interactions yielding two charged secondaries with at least one kink and an associated neutral-decay vee, which were candidates for the chains of decay

\[
\Omega^+ \rightarrow \Xi^+ \pi^+
\]

\[
\Lambda^0 \pi^+
\]

\[
\overline{\Lambda}^0 \pi^+
\]

(1)

\[
\Omega^+ \rightarrow \Lambda^0 K^+
\]

\[
\overline{\Lambda}^0 \pi^+
\]

(2)

and

\[
\Xi^+ \rightarrow \Lambda^0 \pi^+
\]

\[
\overline{\Lambda}^0 \pi^+
\]

(3)

These events were digitized on a conventional Franckenstein and then spatially reconstructed and kinematically fitted in the program TVGP-SQUAW on the CDC 6600 computer$^{12)}$. Each event was fitted to all decay hypotheses, as well as to multivertex hypotheses for the production and the entire decay chain involving all possible hyperons and antihyperons.

For this sample of film we have a total path length equivalent to approximately 0.2 \(\mu\)b per event. No event has been observed which is kinematically consistent with the hypothesis of antiomega production and with decay via channels (1) or (2). One event observed in either decay mode would imply a production cross section of about 0.5 \(\mu\)b$^{13)}$.

Twelve charged antixi events were identified for which the complete chain of decay (3) was visible$^{14)}$. In Table I we list the cross section of the final states into which these twelve events are distributed$^{15)}$. The mass of the antixi was also fitted from its decay products for each event,
and a weighted average of these events gives \( M(\Xi^+) = 1321.7 \pm 0.6 \, \text{MeV} \). Here the error quoted is the statistical error only, as we do not yet have a reliable estimate of the possible systematic error. The lifetime of the antixi obtained from our measurements is \( \tau(\Xi^+) = (1.2^{+0.7}_{-0.2}) \times 10^{-10} \, \text{sec} \), which was obtained by a maximum-likelihood technique. The likelihood function is defined as

\[
L(\tau) = \prod_{i=1}^{N} \frac{\exp\left(-\frac{t_i}{\tau}\right)}{\tau \left[ \exp\left(-\frac{t_{i \text{min}}}{\tau}\right) - \exp\left(-\frac{t_{i \text{max}}}{\tau}\right) \right]},
\]

in which \( \tau \) is the assumed lifetime, \( t_i \) is the observed lifetime for each event, \( t_{i \text{min}} \) is the lower limit due to minimum observable track length in the bubble chamber (0.5 cm), and \( t_{i \text{max}} \) is the upper limit due to the finite fiducial volume.

We have also investigated the antixi production mechanism (\( B = -1 \) and \( S = +2 \)) from interactions with the initial \( K^+p \) state (\( B = +1 \) and \( S = +1 \)). Two possible diagrams we have considered are shown in Fig. 1. Figure 1a shows the peripheral production of a hypothetical intermediate boson state with \( S = +1 \), which decays subsequently into \( \Xi^+ \Lambda^0 \) or into \( \Xi^+ \Sigma^0 \), and Fig. 1b shows the interaction with hyperon exchange. This second diagram would be favored if states with \( B = 2 \) and \( S = -1 \) existed.

In Fig. 2 we show a Dalitz plot in which \( M^2(\Xi Y) \) is plotted against \( M^2(YN) \) for all events. For reactions (A) through (E), \( Y \) refers to \( \Sigma \), \( \Lambda \), or missing mass of \( S = -1 \), whereas for reactions (F) and (G) \( Y \) refers to \( \Lambda \) and \( \Lambda \). The two envelopes corresponding to the kinematical boundaries of the final states \( \Xi^+p \) and \( \Xi \Lambda M(1650)p \) are drawn to illustrate the dependence of the kinematical boundary on the rest energy of the final states. We find no clear indication of any resonant states in either \( \Xi Y \)
or YN systems. The production angular distributions as well as the correlations between the production angles of the final-state particles are shown in Fig. 3. It appears that there are no strong correlations and that all distributions are consistent with isotropy.

We thank R. Shutt and the staff of the 80-Inch Bubble Chamber and H. Foelsche and the AGS Staff for helping with our exposure. We thank B. Sheldon for coordinating the scanning and measuring. We also thank R. W. Bland, J. A. Kadyk, and G. H. Trilling for important contributions in the earlier stages of the experiment. Finally we acknowledge the excellent effort of our programming staff, in particular J. Alvarez and E. R. Burns.
FOOTNOTES AND REFERENCES

+ Work done under the auspices of the U.S. Atomic Energy Commission
* Present Address: Stanford Linear Accelerator Center, Stanford, California


7) The production of $\bar{\Lambda}$ in $K^+$ interactions has been reported by G. Bassonpierre, Y. Goldschmidt-Clermont, A. Grant, V. P. Henri, B. Jongejans, R. L. Lander, D. Långlin, F. Muller, J. M. Perreau, A. Prokes, R. Sekulin, J. K. Tuominiemi, W. de Ruere, J. Debaisieux, P. Dufour, P. Grard,
J. Heughebaert, L. Pape, P. Peeters, F. Verbeure, and R. Windmolders, Nuovo Cimento 48A, 589 (1967);


9) A study of antilambda production will be presented in a future communication.


11) The Berkeley camera system was developed by Duane Norgren and Daniel Curtis. We wish to thank Curtis for his contribution during the exposure at the AGS.


13) The cross section is estimated for the reaction $K^+ p \to \bar{\Lambda}^+ \Lambda^0 \Sigma^+$ and corrected for invisible $\Lambda^0$ and $\bar{\Lambda}^0$ decays. The threshold for this reaction is 3.98 BeV, whereas the cm. energy in this experiment is 4.26 BeV.

14) We have not searched for $\Xi^0$ events because the decay fit is under-constrained.
15) Two events of the reaction $K^+ p \rightarrow \Xi^+ n$ can also be interpreted as $\pi^+ p \rightarrow \Xi^+ \Sigma^+ \Lambda^0$. The upper limit of pion contamination in this experiment is 1.3%, and this would imply a lower limit to the cross section of 90 µb, which makes this interpretation rather unlikely.
FIGURE CAPTIONS

Fig. 1  Two possible diagrams for antixi production involving (a) boson exchange and (b) hyperon exchange.

Fig. 2  Dalitz plot for the 12 antixi events. The envelopes are the kinematical boundaries for the final states $\Xi\Lambda p$ and $\Xi\Lambda(1650)p$. The two final states $\Xi^{+}\Lambda^{0}n$ and $\Xi^{+}\Lambda^{0}p$ are each represented by two points, one for each of the two possible mass combinations $\Xi\Lambda$ and $\Xi\Lambda\pi$.

Fig. 3  Angular distributions for the 12 antixi events. The two final states $\Xi^{+}\Lambda^{0}n$ and $\Xi^{+}\Lambda^{0}p$ are each represented by two points, one for each of the two possible mass combinations, $\Xi\Lambda$ and $\Xi\Lambda\pi$. 
<table>
<thead>
<tr>
<th>Reaction</th>
<th>Final State</th>
<th>No. of Events</th>
<th>Cross Section (µb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$\Xi^+\Lambda^-p$</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>2</td>
<td>$\Xi^+\Sigma^-p$</td>
<td>2</td>
<td>0.8</td>
</tr>
<tr>
<td>3</td>
<td>$\Xi^+\Lambda^-np$</td>
<td>3</td>
<td>0.8</td>
</tr>
<tr>
<td>4</td>
<td>$\Xi^+\Sigma^-n$</td>
<td>3</td>
<td>1.6</td>
</tr>
<tr>
<td>5</td>
<td>$\Xi^+\Sigma^-mm$</td>
<td>1</td>
<td>0.6</td>
</tr>
<tr>
<td>6</td>
<td>$\Xi^+\Lambda^-\pi^-n$</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>7</td>
<td>$\Xi^+\Lambda^-\pi^-p$</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>All Events</td>
<td>12</td>
<td>5.3</td>
</tr>
</tbody>
</table>
Fig. 1

(a) $K^+ \rightarrow K^* \rightarrow \Xi, \Lambda, \Sigma \rightarrow p$, Meson

(b) $K^+ \rightarrow \Xi, \Lambda, \Sigma \rightarrow p$, Hyperon

XBL678-3885
Fig. 2
Fig. 3

\[ K^+ p \rightarrow \Xi^+ Y N \]

\[ 9.0 \text{ BeV/c} \]
This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.