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E- PRODUCTION BY K- MESONS

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Authors
Fowler, William B.
Birge, Robert W.
Eberhard, Phillippe
et al.

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Ernest O. Lawrence

Radiation Laboratory

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\( \beta^- \) PRODUCTION BY K^- MESONS


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The Berkeley 30-inch propane chamber was operated in a 1.17-Bev/c $K^-$ beam at the Bevatron to produce cascade particles. Out of the 100,000 pictures taken there have been 18 positively identified negative cascade decays with the decay mode $\Xi^- \rightarrow \Lambda + \pi^-$. Of these, six were produced with a $K^+$ meson and three were accompanied by a visible $\theta_1$ decay. Three of the events with a $K^+$ satisfy the kinematics for the hydrogen interaction

$$K^- + p \rightarrow \Xi^- + K^+,$$

and the other three are assumed to have been produced from protons in carbon. Two of the $K^+$ decayed in the chamber and the other four were identified by comparing momentum and ionization. Since only one-third of the $K^0$ produced in the interaction

$$K^- + n \rightarrow \Xi^- + K^0$$

decay into a visible mode, it is quite consistent to attribute the nine events in which no positive-strangeness $K$ particle was observed to the neutral mode of the $\theta_1$ decay, to the $\theta_2$ decay, or to a $K^+$ that could not be distinguished from a proton.

The 18 events were selected from a sample of 47 in which a $V$ particle was thought to come from a prong of a $K^-$ interaction which appeared to decay into a $\pi^-$. The selection consisted of a series of two single-origin constraints on an IBM 704 calculator: (a) the $Q$ of the $V$ particle was required to be consistent with that of a $\Lambda$, 37 Mev, and its line of flight consistent with the assumed $\Xi^-$ decay origin; (b) the $\Lambda$ and the $\pi^-$ were required to be coplanar with the assumed $\Xi^-$ and to balance transverse momentum. Revised estimates
of the momentum and angles of the $\Delta$ and $\pi^-$ were obtained from the
constraint program and the average mass of the $\Xi^-$ for the 18 surviving events,
weighted by the estimated probable error of each event, was found to be

$$M_{\Xi^-} = 1317.9 \pm 1.9 \text{ Mev.}$$

The mean life of the $\Xi^-$ has been determined by means of a modification
of the statistical method of Bartlett \(^2\) which accounts for the necessity of seeing
the $\Delta$ decay before the $\Xi^-$ leaves the chamber. The possible time for decay
was determined by calculating the time of flight to the boundary of the fiducial
region, which was chosen to allow a minimum of 4 cm for the measurement of
the $\Delta$ decay. In all cases the correction due to finite chamber size is small,
and the total correction amounts to less than 10% of the uncorrected mean of the
actual flight times. The flight times include $dE/dx$ corrections and the possible
times were modified for those cases in which the $\Xi^-$ would have come to rest
before leaving the chamber. Figure 1 shows a plot of Bartlett's $S$ function as
a function of $1/\tau$. This function is zero at the most probable lifetime and at
the best estimate of the standard error. Figure 2 is a cumulative histogram of
the calculated times of flight, $t_1$, and indicates a considerable scanning bias
against flight times less than $0.5 \times 10^{-10}$ sec. An estimate of the total number
of events was obtained by fitting those events with a time of flight greater than
$0.5 \times 10^{-10}$ sec to the exponential $N_0 e^{-t/\tau}$. The revised mean life consistent
with this procedure required the addition of seven events in the interval from
zero to $0.5 \times 10^{-10}$ sec, and was found to be

$$\tau = 1.28 \times 10^{-10} \pm 0.41 \pm 0.25 \text{ sec.}$$

The $S$ function corrected for scanning bias is shown as the solid line $b$ in
Fig. 1. This mean life is considerably shorter than that found by Trilling and
Neugebauer. \(^3\) However, their events at high cascade momentum required much
greater corrections for chamber size. The dotted line $c$ in Fig. 1 shows the $S$
function for their six events combined with our 25 (including corrections for
scanning bias), and it is seen that the combined mean life falls within our error.
A violation of parity conservation in the cascade decay will manifest itself as a fore-aft asymmetry in the \( \Lambda \) decay, the \( K^- \) serving to polarize the \( \Lambda \) with the strength \( a_{\bar{K}\Lambda} \) which is then analyzed by the \( \Lambda \) decay. Denoting the direction of the \( \Lambda \) in the \( K^- \) rest frame as \( \hat{\Lambda} \) and the direction of the proton in the \( \Lambda \) center of mass as \( \hat{P} \), the distribution of \( \hat{\Lambda} \cdot \hat{P} \) is

\[
P (\hat{\Lambda} \cdot \hat{P}) \, d (\hat{\Lambda} \cdot \hat{P}) = \frac{1}{2} \left[ 1 + \left( a_{\bar{K}\Lambda} \right) \, \left( \hat{\Lambda} \cdot \hat{P} \right) \right] \, d (\hat{\Lambda} \cdot \hat{P}).
\]

We have found, on the basis of the above 18 events,

\[
(a_{\bar{K}\Lambda}) = -0.65 \pm 0.35,
\]

using \( (a_{\bar{K}\Lambda}) = \frac{3}{N} \sum (\hat{\Lambda} \cdot \hat{P}) \) as the best estimator. The negative sign shows the helicity of the \( \Lambda \) from the \( K^- \) to be opposite to that of the proton from \( \Lambda \) decay. \(^5\) Birge and Fowler \(^5\) find the helicity of the proton to be positive, implying that the helicity of the \( \Lambda \) is negative. Using the best estimate of the magnitude \( |a_{\bar{K}\Lambda}| \) is \( 0.69 \pm 0.35 \) and the sign of \( \rho_\Lambda \) as determined by Birge and Fowler, we find

\[
a_{\bar{K}} = 0.69 \pm 0.36.
\]

The possibility of an up-down asymmetry of the decay \( \pi^- \) from \( K^- \) to \( \Lambda + \pi^- \) produced in the reaction

\[
K^- + N \rightarrow K^- + K
\]

has been examined, and \( (a_{\bar{K}\pi}) \) is \(-0.28 \pm 0.40 \) where \( P \) is the polarization of the \( K^- \) in production and \( a_{\bar{K}} \) the decay asymmetry parameter. There seems to be no indication that the \( K^- \) produced in this manner from carbon are polarized.
In the 100,000 pictures we had a total of $1.5 \pm 0.2 \times 10^7$ cm of $K^-$ track length. After adding seven events to correct for scanning bias and then 50% to correct for the unobserved neutral decay mode of the $\Delta$, we estimate the total number of $\Xi^-$ to be 37.5. On this basis the $\Xi^-$ production cross section in the reaction $K^- + N \rightarrow \Xi^- + K$ is

$$\sigma_{\Xi^-} = 18 \pm 5 \mu\text{b/nucleon},$$

assuming an $A^{2/3}$ correction for shielding in the carbon nucleus.
FOOTNOTES AND REFERENCES

*Brookhaven National Laboratory, Upton, L. I., N. Y.

†Ecole Polytechnique, Laboratoire de Physique, Paris, France.

§College de France, Laboratoire de Physique, Berthelot, Paris, France.

**University of Wisconsin, Physics Department, Madison, Wisconsin.

††University of California, Physics Department, Los Angeles, California.

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6. Frank S. Crawford, Jr. (Lawrence Radiation Laboratory), private communication.
Fig. 1. Bartlett's $S(\tau)$ function with a $\Delta$ lifetime correction for (a), the 18 observed $\Xi^-$ from this experiment, (b) this experiment corrected for scanning bias, and (c) the corrected data of this experiment combined with six events from Trilling and Neugeberger. 3

Fig. 2. A cumulative histogram of the times of flight of the $\Xi^-$. The solid line is the best fit of those events with $t_i > 0.5 \times 10^{-10}$ sec to an exponential.