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OBSERVATION OF CASCADE HYPERON INTERACTIONS

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ABSTRACT

We report on the observation of 17 Ξ^0 + p interactions in the Berkeley 72" Hydrogen Bubble Chamber. Cross-sections are calculated for both elastic and inelastic channels.

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Although the existence of the cascade hyperon (Ξ particle) has been known since 1953, there have been virtually no reports of its interactions. There have been many studies of the interactions of other strange hyperons; the neglect of the Ξ particle comes not from lack of interest but rather from lack of particles. Because of its low production cross-section, the total length of Ξ tracks produced in hydrogen bubble chambers, for example, is probably less than 1000 meters. We thought that it might be interesting to look at the interactions of such strange particles.

We made a search for Ξ interactions in film taken in an exposure of the Berkeley 72" bubble chamber to K^- particles in 1963. The production and decay characteristics of the Ξ's from this exposure have been reported previously.[1] During the initial phases of this work, the first published cross-sections for elastic $\Xi^- + p$ scattering was reported by Charlton et al.[2] and by the Amsterdam-Nijmegen Collaboration.[3] We report here the observation of $4\Xi^- + p$ and $13\Xi^0 + p$ interactions. Thirteen of these interactions were in inelastic channels. The momenta of the Ξ's ranged from a low of 0.5 GeV/c to a high of 2.8 GeV/c. The average momentum of the Ξ's in the chamber was 1.3 GeV/c; the average momentum of the Ξ's which interacted was 2.0 GeV/c. The higher average momentum of the interacting sample indicates a cross-section which rises with energy.

Ξ interaction topologies were too rare to have been included as an event type in the original scanning of the film, done soon after the 1963 exposure. However there was a special category for peculiar events (traditionally called " zoo-ons "), and it was into this category that most of the Ξ interactions should have been classified. We made a special scan of several thousand zoo-ons, and found 32 candidates

for Ξ interactions. Of the 17 which we eventually called true Ξ interactions, all but two had been tagged as zoo-ons on both scans. Thus the overall scanning efficiency was close enough to 100% that scanning bias errors were negligible compared to our statistical errors. There were not enough events to permit a topology-dependent calculation of scanning efficiency.

All candidates were measured at least three times, kinematically fit with the program SIOUX, and re-scanned for consistency with predicted ionization. Particular care was taken to try non-Ξ hypotheses on those events that had a good fit to a Ξ interaction hypothesis. Kinematic fits were accepted if they had a confidence level of 1% or better.

The results of our search are summarized in Table 1. In order to be sure that an event represented a Ξ interaction, we required (depending on the event type) (a) that a K^+ or visible K^0 was produced along with the Ξ, and/or (b) that a visible Λ was seen in the final state. The column marked " signature " indicates which conditions were placed on each event type. For the determination of interaction cross-sections we could use only those events for which we knew the total pathlength of Ξ's in our exposure. Thus, for example, we could not use Ξ^0's that were produced in the particular reaction $K^- + p \to \Xi^0 + K^0 + \pi^0$ (even if the Ξ^0 interacted and the K^0 decayed), because we did not know the rate at which Ξ^0's are produced in this reaction. The number of events for each reaction type that could be used for the cross-section determination is listed in the next column of the table. Pathlength of the Ξ's was determined for each signature type, using the data of reference 1. Cross-sections for each reaction (corrected for unseen events) are listed in the last column. In all cases the errors are determined by statistics; scanning losses and other systematic errors are negligible. Rather than specify an error for each reaction cross-section, we simply give the number of events used in its computation.

Our elastic Ξ^0 + p interaction cross-sections are compatible with those published previously.[2,3] Inelastic cross-sections have never been published before. It is interesting to note that interacting Ξ^0's are relatively easy to identify, even though Ξ^0's that decay (because they decay into neutrals) are difficult to identify. For the $\Xi^0 + p$ interaction our total observed cross-section is 61 ± 20 mb; the total cross-section should include contributions from such final states as $\Xi^0 + p + \pi^0$.

Only in one reaction, $\Xi^0 + p \rightarrow \Lambda + \Sigma^+$, were there sufficient events to warrant looking at the angular distribution. For this reaction, the center of mass angular distribution was consistent with a flat distribution: the cosines of the angle between the incoming Ξ^0 and the outgoing Λ were -0.69, -0.45, -0.05, 0.05, 0.15, and 0.80 for the six events. The total observed cross-sections for Ξ^0 + p is of the same order as other baryon-baryon cross-sections; at this stage of investigation there seems to be nothing peculiar about Ξ interactions.

Peter Cook deserves special mention for his excellent computer programming and careful scanning, and for his initiative in these investigations. I wish also to thank Luis Alvarez for suggesting and encouraging this work.

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Table 1

reaction	events*	signature	cross-section events **	cross-section (mb)
$\Xi^0 + p \rightarrow \Xi^0 + p$	2	K, Λ	1	8
$\Xi^0 + p \rightarrow \Lambda + \Sigma^+$	6	Λ	4	24
$\Xi^0 + p \rightarrow \Sigma^0 + \Sigma^+$	1	Λ	1	6
$\Xi^0 + p \rightarrow \pi^+ + \Lambda + \Lambda$	1	K, Λ	1	6
$\Xi^0 + p \rightarrow \pi^0 + \Lambda + \Sigma^+$	1	Λ	1	6
$\Xi^0 + p \rightarrow \pi^+ + \Xi^- + p$	1	K or Λ	1	5
$\Xi^0 + p \rightarrow \pi^+ + \pi^+ + \Xi^- + n$	1	K, Λ	1	6
$\Xi^0 + p \rightarrow \Xi^- + p$	2	Λ	2	8
$\Xi^0 + p \rightarrow \Sigma^- + \Sigma^+$	1	K	1	4
$\Xi^0 + p \rightarrow \Sigma^- + K^0 + p$	1	K	1	4

* Confidence level from SIOUX ≥ 1% .

** Includes only those events for which a Ξ pathlength could be calculated.

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