NEUTRAL HYPERON EXPERIMENTS

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A Λ^o hyperon has a mean lifetime in its rest system of approximately 2.5×10^{-10} sec, but a Λ^o of momentum 200 GeV/c travels 13.8 m in the laboratory. In this distance, it is feasible to build a well-defined beam and to study the interaction of neutral hyperons with matter. Thus the reaching of energies of several hundred GeV at Fermilab has made possible a new and varied experimental program with short-lived particles.

This work began at Fermilab with Experiment 8, a collaboration of Michigan, Rutgers, and Wisconsin. There have been many results of physics interest from Experiment 8 and its successors and this article will review these results briefly.

The experiment began by studying the inclusive production of Λ^o's and other short-lived neutral particles by 300 and 400 GeV protons on a metal target, that is, reactions of the form $p + A \rightarrow \Lambda^o + X$, where X represents any possible (unobserved) final state that can accompany the hyperon. It was found that Λ^o's produced in this way are polarized.[1] That is to say that the spins and magnetic moments of the hyperons are preferentially aligned. At first, this result was surprising, because it was thought that averaging over all possible final states X would tend to smooth out the details of the production process and give no net polarization. Since this discovery, however, similar effects have been observed at other energies[2] and in other inclusive channels.[3]

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A follow-up experiment, E-441, has been performed using a liquid hydrogen production target, $p + p \rightarrow \Lambda^o + X$, to study the dynamics of the polarization process in more detail in search of clues to its origin. Meanwhile, the effect has been exploited in E-440 to make a precision measurement (better than 1% accuracy) of the magnetic moment of the Λ^o. An experiment is planned which will use the polarized beam to study the beta decay $\Lambda^o \rightarrow p + e^- + \bar{\nu}_e$.

The production measurements were originally made with beryllium, copper, and lead targets, which resulted in data on the A (atomic mass) dependence of the inclusive reactions. This A dependence has been described by a simple collision model in which the outgoing hadronic system loses energy by collision with target nucleons as it leaves the nucleus.[4]

The hyperon beam contains other neutral particles as well. In order of decreasing intensity, the beam composition is n, γ, Λ^o, K^o_s, $\overline{\Lambda^o}$, Ξ^o, and $\overline{\Xi^o}$, all of which have been observed in E-8. Particular interest has centered on the $\overline{\Lambda^o}$'s, which are not polarized, but are fairly numerous (greater than 1% of the Λ^o's), and the Ξ^o's. The Ξ^o hyperon has a lifetime comparable to the Λ^o and decays into two neutrals: $\Xi^o \rightarrow \Lambda^o + \pi^o$ followed by $\pi^o \rightarrow \gamma + \gamma$ and $\Lambda^o \rightarrow p + \pi^-$. The final state has a complicated topology and both γ rays plus the daughter Λ^o decay were observed in order to unravel the decays. A sample of about 6000 Ξ^o hyperons has been collected, giving a new measurement of the asymmetry parameter $\mathcal{L}_{\Xi^o}$.[5] A new experiment, E-495, is scheduled to run in the spring of 1978, and will concentrate on Ξ^o hyperons, including a search for possible polarization and a first measurement of the magnetic moment.

Experiment 415 was performed in collaboration with a group from Colorado to round out the production studies by measuring the spectra of neutrals produced by 200-GeV π^-, K^-, and $\bar{p}$ beams.[6] This experiment showed that a "clean" K^o beam could be produced by π^-, free of high-energy neutrons.

In another phase of the program, a hydrogen target was inserted in the neutral beam itself to measure cross sections for Λ^o, K^os, and $\overline{\Lambda^o}$. Over 10^5 $\Lambda^o p$ elastic scatters were collected in the momentum transfer range $0.05 \leq - \leq 1.5$ (GeV/c).[2] Both the elastic differential cross section[7] and the Λ^o polarization[8] have been obtained.

Many aspects of the program are continuing, with emphasis in the future on high transverse momentum production phenomena and rare decay-mode studies made possible by the intensity up-grade in the Meson Laboratory.

References

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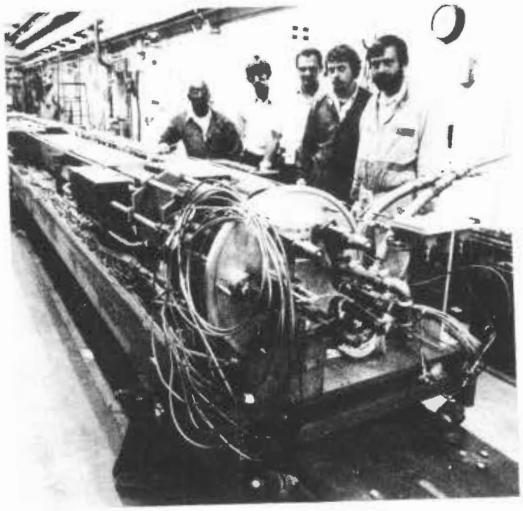

The new Meson Target Train Mark II prior to installation. The builders are (left to right) John Williams, Roger Tokarek, Anthony Glowacki, Robert Jensen, and Henry Koecher.