

SEARCH FOR POLARIZATION IN $\bar{\Xi}^0$ HYPERONS

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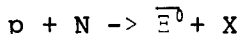
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Abstract

Inclusive hyperon production by 400 GeV protons at Fermilab has shown that the hyperons are produced with significant polarization. However no polarization has been seen for $\bar{\Lambda}$'s produced at these energies. In this paper we present the results of a search for $\bar{\Xi}^0$ polarization.

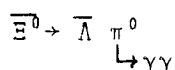
$\bar{\Xi}^0$ hyperons, obtained from two independent experiments, have been analyzed for inclusive polarization. The data consist of 4,529 fully reconstructed events and 23,500 events obtained from non-target pointing $\bar{\Lambda}$'s. In both experiments the hyperons were produced in the inclusive reaction



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The Ξ^0 decay sequence is



The events in the later sample were obtained from an experiment to measure the inclusive polarization of Λ hyperons at high transverse momentum ($p_t > 2.0$ GeV/c). Details of this experiment have been presented at this conference¹. Since the ratio of Ξ^0 to Λ hyperons increases with production angle, a fair fraction of Ξ^0 's were expected in the high p_t experiment. It is also found at high p_t that the fraction of anti-particles in the beam also increases. For example the ratio of $\bar{\Lambda}$ to Λ increases from 1/40 to 1/3 when the production angle is increased from 7.7 mrad to 20.0 mrad. Hence a fair fraction of Ξ^0 's were also expected from this experiment. Indeed a large sample of Ξ^0 's and $\bar{\Xi}^0$'s was observed.

The experimental apparatus consisted of a magnetic spectrometer for charged particle detection. Since there was no π^0 detection the Ξ^0 's and $\bar{\Xi}^0$'s could not be fully reconstructed. The events were selected using a "large R^2 technique", which was the method used in the first measurement of the Ξ^0 magnetic moment². This method selects Λ 's and $\bar{\Lambda}$'s whose momentum vectors do not project to the hyperon production target. The criteria used to select such events is that the square of the radial distance of the projected momentum vector in the plane of the production target be $80 \text{ mm}^2 < R^2 < 360 \text{ mm}^2$. There are several characteristics of this sample which can be used to determine its purity. The daughter Λ 's ($\bar{\Lambda}$'s) should have a lower average momentum than target pointing Λ 's, and the vertex distribution of daughter Λ 's occurs downstream of the beam Λ 's and therefore should have the characteristic shape of the daughter decay vertex. Both of these criteria were met by the Ξ^0 and $\bar{\Xi}^0$ samples. An estimate of the background in both samples is about 10%.

The major problem in the analysis of these data samples was that, due to the nature of the production cross section at high p_t , the average momentum of the Λ 's and $\bar{\Lambda}$'s is less than 70 GeV. The spectrometer acceptance for Λ 's (and hence large R^2 Ξ^0 's and $\bar{\Xi}^0$'s) below 80 GeV is less than 50%. The poor momentum acceptance affects polarization measurements, particularly in the z direction, which is the momentum dependent asymmetry. In the present analysis, the z component of the polarization is measured with only half the sensitivity as the x and y components.

Since the Ξ^0 polarization has been well measured

³, the polarization of the large R^2 sample of Ξ^0 's (56,700 events) was analyzed to determine the feasibility of measuring the polarization of the Ξ^0 's. By determining the x_f and p_t of the Ξ^0 sample ($x_f = 0.2$, $p_t = 1.7$ GeV/c) the magnitude of the polarization could be predicted using the results of the Λ polarization in the same kinematic region¹.

Since only the Λ decay of the Ξ^0 decay sequence is observed, the Ξ^0 polarization is determined from the measured asymmetry in the Λ decay distribution. The Λ and Ξ^0 asymmetries are related by

$$\alpha_{\Lambda} \vec{P}_{\Lambda} = 1/3 \alpha_{\Xi} (1 + 2 \gamma_{\Xi}) \vec{P}_{\Xi}$$

The predicted magnitude for the asymmetry $\alpha_{\Lambda} P_{\Lambda}$ was 0.035. The small value of this magnitude is a reflection of the low x_f value of the sample. The direction of the Ξ^0 polarization is a function of polarization direction at production and the precession angle of the polarization in the magnetic field in the neutral beam collimator. This direction was predicted using the Ξ^0 magnetic moment and the magnetic field strength. The precession angle of the polarization vector is given by

$$\theta_p = -18.3 \mu_{\Xi^0} \int \vec{B} \cdot d\vec{l}$$

Using $\mu_{\Xi^0} = 1.253 \pm 0.014$ ⁴ and $\int \vec{B} \cdot d\vec{l} = 12$ T-m, a precession angle of 275° is predicted. Since the initial polarization was along the y direction and the precession occurs in the y-z plane, the measured Ξ^0 polarization was predicted to be along the z direction. This direction and predicted magnitude were observed. The asymmetries in the x and y directions were zero within $\sigma = 0.007$. The z asymmetry was measured to be -0.029 ± 0.014 . Due to the poor momentum acceptance the statistical error on the measurement was large.

For the Ξ^0 events the same analysis was performed. The results were essentially inconclusive due to large statistical errors. Since the Ξ^0 sample has $x_f = 0.14$ and $p_t = 1.2$ GeV/c, even a smaller asymmetry than in the Ξ^0 would be expected if the particles were polarized. The asymmetries measured were all within one σ of zero. From this data sample (which is $\approx 2/3$ of a final data sample which is still being analyzed) it can be concluded that the Ξ^0 polarization is not unexpectedly large.

However, one of the motivations for analyzing Ξ^0 polarization in the large R^2 events, was an indication in the fully reconstructed events that there was a significant polarization signal. A total of 4,529 events were divided among four running conditions under

which the direction of any polarization in the sample was reversed when the direction of the production angle was reversed. In addition, the z component of a polarization vector was reversed when the direction of the precession field was reversed. Biases in the asymmetry measurements do not reverse when these conditions change, hence any real polarization is obtained by appropriately subtracting the measured asymmetries. Unfortunately, the statistical weight of each sample was not equivalent, leading to concern over systematic effects in the sample which were not understood. The measured asymmetries for each of the conditions are listed in Table 1.

Table 1 Measured asymmetries for fully reconstructed $\bar{\Xi}^0$

$\int \vec{B} \cdot d\vec{l}$	x-asymmetry		z-asymmetry	
	+	-	+	-
θ_p				
+	-0.12 ± 0.11	$+0.01 \pm 0.07$	-0.02 ± 0.15	-0.13 ± 0.10
-	$+0.14 \pm 0.06$	$+0.10 \pm 0.04$	-0.17 ± 0.08	-0.04 ± 0.05

Conclusion

We have described our search for inclusive polarization in the $\bar{\Xi}^0$ hyperon. The present status of the analysis leaves the question unresolved since the two experiments obtain different results, but also examine different kinematic regions. The high statistics experiment presents data where any polarization is expected to be small, thus requiring much better sensitivity to extract a conclusion. Large R^2 data are being analyzed where the x_f value is larger. The absence of polarization in $\bar{\Lambda}$ hyperons produced by protons on nuclear targets makes the question of polarization in other anti-particles an interesting one though difficult to answer.

1. B. Lundberg, contributed paper to this conference.
2. G. Bunce, et. al., Phys. Lett. 86B, 386 (1979)
3. P. T. Cox, PhD Thesis, University of Michigan, UM HE 80-19 (1980)
4. P. T. Cox, et. al., Phys. Rev. Lett. 46, 877 (1981)