CBPF-NF-009/97

The Λ_0 Polarization and the Recombination Mechanism*

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Abstract

We use the recombination and the Thomas Precession Model to obtain a prediction for the Λ_0 polarization in the $p + p \rightarrow \Lambda_0 + X$ reaction. We study the effect of the recombination function on the Λ_0 polarization.

Key-words: Polarization-recombination, Thomas precession.

*This work was partially supported by Centro Latino Americano de Física (CLAF).
Talk presented at I Simposium Latinoamericano de Física de Altas Energias (SILAFAE), Merida, Mexico, November 1996.

1 Introduction

The unexpected discovery of large polarization in inclusive Λ_0 production by unpolarized protons has shown that important spin effects arise in the hadronization process. Several models have been proposed to explain hyperon polarization, being the Thomas Precession Model (TPM)[1] one of the most extensively used to describe polarization in a variety of reactions.

In order to obtain the Λ_0 polarization, we first calculate the momentum fraction of the recombining s-quark in the proton sea using a recombination model [2]. We use two different forms for the recombination function to see their influence on the predicted Λ_0 polarization.

2 The Λ_0 polarization in the TPM

In pp collisions the recombining s-quark resides in the sea of the proton and carries a very small fraction $x_s \simeq 0.1$ of the proton momentum. When the s-quark recombines to form a Λ_0, it becomes a valence quark and must carry a large fraction (of the order of $\frac{1}{3}$) of Λ_0's momentum. Then one expects a large increase in the longitudinal momentum of the s-quark as it passes from the proton to the Λ_0,

$$\Delta p \simeq (\frac{1}{3}x_F - x_s)p = \left(\frac{1}{3} - \xi\right) x_F p, \tag{1}$$

where p is the proton's momentum, $\xi = x_s/x_F$ and $x_F p = p_\Lambda$ is the momentum of the Λ_0 with x_F the Feynman x.

Since the s-quark carries transverse momentum, on the average $p_T(s/p) \sim p_T(s/\Lambda) \sim \frac{1}{2}p_{T\Lambda}$, its velocity vector is not parallel to the change in momentum induced by recombination and it must feel the effect of Thomas precession. Consequently, the Λ_0 is produced with net polarization perpendicular to the plane of the reaction.

According to the TPM the Λ_0 polarization in the reaction $p + p \to \Lambda_0 + X$ is given by[1]

$$P(p \to \Lambda) = -\frac{3}{M^2 \Delta x} \frac{(1-3\xi)}{\left(\frac{1+3\xi}{2}\right)^2} p_{T\Lambda}, \tag{2}$$

where $M^2 = \left[\frac{m_D^2 + p_{TD}^2}{1-\xi} + \frac{m_s^2 + p_{Ts}^2}{\xi} - m_\Lambda^2 - p_{T\Lambda}^2\right]$ and $\xi = \frac{1}{3}(1 - x_F) + 0.1 x_F$ as was assumed in ref. [1]. $\Delta x = 0.5$ GeV is a characteristic recombination scale and m_D, p_{TD}, m_s, p_{Ts}, m_Λ and $p_{T\Lambda}$ are respectively the masses and transverse momentum of the diquark, the s-quark and the Λ_0.

The $\xi\left(x_F\right)$ parametrization in the Recombination Model

We use the recombination model proposed in ref. [3], which has been extended to take into account baryon production [4], to obtain a parametrization for ξ as a function of x_F[2]. The inclusive x_F distribution for Λ_0's in pp collisions is

$$\frac{d\sigma}{dx_F} = \int \frac{dx_u}{x_u}\frac{dx_d}{x_d}\frac{dx_s}{x_s} F\left(x_u, x_d, x_s\right) R\left(x_F, x_u, x_d, x_s\right), \tag{3}$$

where $F(x_u, x_d, x_s)$ and $R(x_F, x_u, x_d, x_s)$ are the three quark distribution and recombination functions respectively.

For the three quark distribution function we use the factorized form

$$F\left(x_u, x_d, x_s\right) = \beta F_{u,val}\left(x_u\right) F_{d,val}\left(x_d\right) F_{s,sea}\left(x_s\right)\left(1 - x_u - x_d - x_s\right)^{\gamma} \tag{4}$$

with $\gamma = -0.3$ as has been proposed in ref. [4] and $\beta = 0.75$. We used the Field and Feynman [5] parametrizations for the single quark distribution.

In order to see how the shape of the recombination function affects the prediction for the Λ_0 polarization, we use two different forms for $R(x_u, x_d, x_s)$:

$$R_1\left(x_u, x_d, x_s\right) = \kappa_1 \frac{x_u x_d x_s}{\left(x_F\right)^3} \delta\left(\frac{x_u + x_d + x_s}{x_F} - 1\right) \tag{5}$$

as in ref. [4] and

$$R_2\left(x_u, x_d, x_s\right) = \kappa_2 \left(\frac{x_u x_d}{x_F^2}\right)^a \left(\frac{x_s}{x_F}\right)^b \delta\left(\frac{x_u + x_d + x_s}{x_F} - 1\right), \tag{6}$$

which is inspired in the three valons recombination model proposed by R.C. Hwa [6]. In R_2, unlike R_1, the light quarks are considered with different weight than the more massive s quark introducing two distinct exponents a and b. Indeed, in the recombination model proposed in ref. [6], a recombination function for hyperons is derived and a ratio $\frac{a}{b} = \frac{2}{3}$ is used. We choose $a = 1$, $b = \frac{3}{2}$ by fitting experimental data. κ_1 and κ_2 are normalization constants.

The probability for Λ_0 production at x_F with an $s-quark$ from the sea of the proton at momentum fraction x_s is

$$\frac{d\sigma_i}{dx_s dx_F} = \int \frac{dx_u}{x_u}\frac{dx_d}{x_d}\frac{1}{x_s} F\left(x_u, x_d, x_s\right) R_i\left(x_F, x_u, x_d, x_s\right) \tag{7}$$

with $i = 1, 2$. The average value of x_s is therefore [2]

$$\left\langle x_s\right\rangle_i = \left[\int dx_s x_s \frac{d\sigma_i}{dx_s dx_F}\right] / \frac{d\sigma_i}{dx_F}. \tag{8}$$

We have taken $m_D = \frac{2}{3}$ GeV, $m_s = \frac{1}{2}$ GeV and $\langle p_T^2\rangle_{s,D} = \frac{1}{4}p_{T\Lambda}^2 + \langle k_T^2\rangle$ with $\langle k_T^2\rangle = 0.25$ GeV ^{2} [1]. The figure 1 shows the Λ_0 polarization for the three different parametrizations of $\xi(x_F)$ at $p_T = 0.5$ GeV/c.

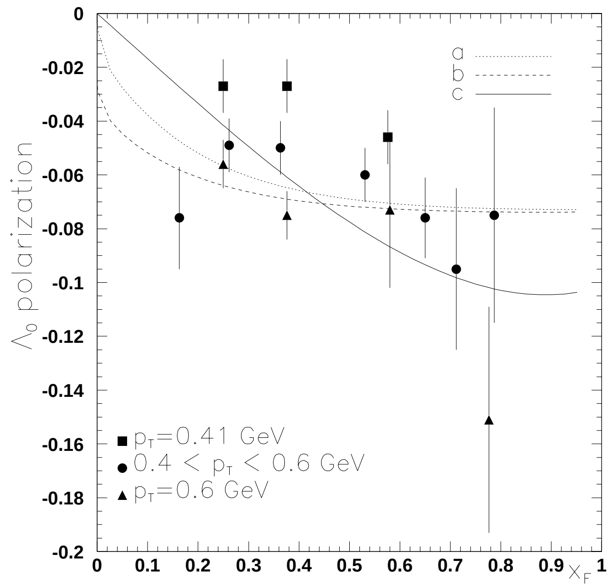

Figure 1: Λ_0 polarization at $p_T = 0.5GeV/c$ obtained with $\xi(x_F)$ determined with the recombination functions R_1 (a), and R_2 (b). (c) is the polarization prediction of ref. [1]. Experimental data are taken from refs. [1] and [7].

3 Conclusions

The two forms for ξ obtained with the two different recombination functions of eqs. 5 and 6 are very similar in shape for large x_F. For small x_F however, the difference grows slightly and $\xi_1\,(x_F = 0) = \frac{1}{3}$ while $\xi_2\,(x_F = 0) \neq \frac{1}{3}$.

The parametrizations for $\xi\,(x_F)$ obtained from the recombination model are different to the simple form proposed in ref. [1]. Our calculation of $\xi\,(x_F)$ shows that, for $x_F \to 1$, $\xi\,(x_F) \to 0.15$ approximately for both recombination functions. This is consistent with our actual knowledge of the sea structure functions in the proton.

We have seen that for small $p_{T\Lambda}$ our fit gives a good description of experimental data. This is reasonable since recombination models work better for small p_T.

Within the precision of experimental data[3][7], it would be hard to decide which recombination function better describe Λ_0's production. A more accurate measurement of polarization at low p_T and low x_F can help to clarify the right form of the recombination function. It is interesting to note that, although the shape of the recombination function is not important for cross section calculations, it does make a difference when applied to polarization. In this sense, polarization measurements can help to understand the underlying mechanisms in hadroproduction.

Acknowledgments

We would like to thank the organizers for financial support to attend the I Simposium Latino Americano de Física de Altas Energías.

References

[1] T. De Grand and H. Miettinen,*Phys. Rev.* **D 23** (1981) 1227, *Phys. Rev.* **D 24** (1981) 2419, T. Fujita and T. Matsuyana, *Phys. Rev.***D 38** (1988) 401, T. de Grand, *ib.* 403.

[2] G. Herrera, J. Magnin, L.M. Montaño and F.R.A. Simão, *Phys. Lett.***B 382** (1996) 201, G. Herrera and L. Montano, *Phys. Lett.***B 381** (1996) 337.

[3] K.P. Das and R.C. Hwa, *Phys. Lett.***B 68** (1977) 459.

[4] J. Ranft,*Phys. Rev.***D 18** (1978) 1491.

[5] R.D. Field and R.P. Feynman, *Phys. Rev.***D 15** (1977) 2590.

[6] R.C. Hwa, *Phys. Rev.***D 22** (1980) 1593.

[7] A. M. Smith et al. ,*Phys. Lett.***B 185** (1987) 209. S. Herhan et al. ,*Phys. Lett.***B 82** (1979) 301.