Strange baryon production asymmetry in $K^\pm N$ interactions

G. H. Arakelyan¹, C. Merino², and Yu. M. Shabelski³

¹ YerPhi, Armenia
² Dpto. de Física de Partículas, Facultade de Física, and IGAE, Universidade de Santiago de Compostela, Galicia, Spain
³ SPNPI, Gatchina, St.Petersburg, Russia

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Abstract. The asymmetry of strange baryon production in $Kp$ interactions at high energies is considered in the framework of the Quark-Gluon String Model. The contribution of the string-junction mechanism to the strange baryon production is analysed.

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The present report is devoted to the calculation of asymmetry of strange baryon production in the case of kaon beams and to the analysis of the contribution of the string-junction (SJ) mechanism in $Kp$ collisions.

It is very important to understand the role of the SJ mechanism in the dynamics of high-energy hadronic interactions, in particular in processes implying baryon number transfer. Significant results on this question were obtained in [1,2,3,4], where the SJ mechanism was used to analyse the strange baryon production in $\pi p$ and $pp$ interactions. The detailed analysis of SJ contribution into strange baryon production in $KN$ interaction was presented in [5].

In the present paper we analyse the existing data on asymmetry of $A$ and $\bar{A}$ production on $K$-beams [6].

We compare the experimental data with the result of our calculations for a value of the SJ intercept $\alpha_{SJ} = 0.9$.

The formulas describing the inclusive spectrum (i.e., Feynman-$x$, $x_F$, distribution) of a secondary hadron $h$ in $KN$ scattering in the Quark Gluon String Model (QGSM) were presented in papers [6,7].

The complete set of distribution and fragmentation functions used in this paper is presented in [5].

The SJ mechanism has a nonperturbative origin and since it is at present not possible to determine the value of $\alpha_{SJ}$ in QCD from first principles. Thus we treat $\alpha_{SJ}$ and $\varepsilon$ (the weight of the diagramm describing the SJ contribution, see [5]) as phenomenological parameters which should be determined from experimental data. In the present calculation, we use the values $\alpha_{SJ} = 0.9$ and $\varepsilon = 0.024$, as it was done in [2,5,6].

As it was shown in [8], the better agreement of QGSM with data on strange baryon production on nucleus was obtained with $\delta = 0.32$, instead of the previous value $\delta = 0.2$. In principle one cannot exclude the possibility that the value of $\delta$ would be different for secondary baryons and for mesons (i.e., for $A$-baryon and for kaon).

The fragmentation functions into $\bar{A}$ do not depend on the SJ mechanism, so the $\Lambda$ spectra obtained for different values of $\alpha_{SJ}$ are the same, and they have a very small dependence on the strange quark suppression factor $\delta$ (see [5]).

In Fig. 1 we show the comparison of the QGSM calculations with the data on the $\bar{A}/A$ asymmetry $A(\bar{A}/A)$, produced in $K^+p$ (Fig. 1a) and $K^-p$ (Fig. 1b) interactions at 250 GeV/$c$ [3].

The asymmetry data are rather interesting. In the proton fragmentation region the values of $A(\bar{A}/A)$ are close to unity, and that is natural since a proton fragments into $A$ with significantly larger probability than into $\bar{A}$. In the kaon fragmentation region $A(\bar{A}/A)$ becomes negative and decreases very fast in the case of $K^+$ beam at the $x_F$ values where experimental data exist. In the case of $K^-$ beam $A(\bar{A}/A)$ increases very fast with $x_F$ and the variation among calculations with different values of the parameters is rather small. Both these behaviors are also natural since the $K^+$ contains a $\bar{s}$ valence quark which preferably fragments into $A$, while the valence $s$ quark in the $K^-$ fragments rather often into $\bar{A}$. However, in both cases the $A(\bar{A}/A)$ experimental $x_F$-dependencies are much steeper than the theoretical predictions. This is a probable indication that the fragmentation functions $s \rightarrow A$ and $\bar{s} \rightarrow \bar{A}$ should be further enhanced.

In the $K^+$ fragmentation region (Fig. 1a) the predicted values of $A(\bar{A}/A)$ at $x_F > 0.4$ show a change of behavior since they start increasing. In this region the contribution of the direct fragmentation of $\bar{s} \rightarrow \bar{A}$ which makes $A(\bar{A}/A)$

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to decrease becomes smaller than the effect of $SJ$ diffusion which increases the multiplicity of $Λ$. The measurement of the asymmetry $A(Λ/Λ)$ in the region $x_F ≥ 0.4$ in $K^+p$ collisions could make the situation more clear.

The predictions for the asymmetry in $Ξ$ and $Ω$ baryon production in $K^+p$ and $K^-p$ interactions are presented in Fig. 2. Here the general situation is similar to that of the case of asymmetry in $Λ$ production shown in Fig. 1. In Fig. 2 we present the predictions for asymmetries in $Ξ^-$ and $Ω^-$ production in $K^+p$ and $K^-p$ collisions at 250 GeV/c. In the central region of $K^+p$ collisions the yields of $Ξ^-$ and $Ξ^+$ are predicted to be practically the same. The smaller fragmentation function of valence $s$ quark into strange baryon is compensated by the larger fragmentation function of the target diquark. In the case of $K^-$ beam (Fig. 2b) the asymmetry for both $Ξ^-$ and $Ξ^+$, as well as those of $Ω^-$ and $Ω^+$ are predicted to be practically the same. The presence of baryon asymmetry in the projectile hemisphere for $Kp$ collisions provides good evidence for such a mechanism.

The situation for $K^-$ beam seems worse than in the $K^+$ case since all curves are, as a rule, below the experimental data, but both the number and the quality of experimental data on $K^-$ beam are not very high.

The QGSM predicts a weak energy dependence of the $Λ$ and $Λ$ production cross-section in $Kp$ collisions at the considered energies.

The experimental data on high-energy $Λ$ production are not in contradiction with the possibility of baryon charge transfer over large rapidity distances, and the $Λ/Λ$ asymmetry is provided by $SJ$ diffusion through baryon charge transfer.

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