HYPERON POLARIZATION AND SINGLE SPIN ASYMMETRIES IN DIFFERENT HADRONIC REACTIONS [a]

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We show that the polarization of hyperons observed in high energy collisions using unpolarized hadron beams and unpolarized nucleon or nuclear targets is closely related to the left-right asymmetries observed in single spin inclusive hadron production processes. The relationship is most obvious for the production of the hyperons which have only one common valence quark with the projectile. Further implications of the existence of large polarization for hyperon which has two valence quarks in common with the projectile and their consequences are discussed. A comparison with the available data is made. Further tests are suggested.

This talk is a summary of the basic ideas and main results of Refs.[1-3] which have been done in collaboration with C. Boros. In these papers, we show that there should be a close relation between hyperon polarization (P_H) and single-spin left-right asymmetry (A_N) observed in hadron-hadron collisions at high energies. We pointed out that following simple observations and/or arguments seem already suggest this should be true: First, the data [4] for P_H and those for A_N show exactly the same characteristics. Second, both effects show the existence of a correlation between transverse motion and transverse polarization. Hence, unless the polarization of the produced hyperons in the projectile fragmentation region (denoted by PFR in the following) is completely independent of that of the projectile we are practically forced to accept that A_N and P_H are closely related to each other.

For explicity, we considered the questions: Can we understand the existence of P_H and reproduce the main feature of the data if we use A_N as input? Do we need further input(s)? We noted in particular the following:

(I) The A_N data show that meson containing q_v and a suitable anti-sea-quark $\bar{q}_s$ has a large probability to go left if q_v is upwards polarized. (We denote the difference of the probability for such a meson to go left and that to go right by C.] We assume that this is also true for the produced baryon which contains such a q_v and a sea diquark.

(II) Recent measurements [5] of Λ polarization from Z^0 decay show that, in the longitudinally polarized case, quark polarization remains the same before and after the hadronization. We assume that this is true not only for Λ but also for other hyperons and also in the transversely polarized case.

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We first considered the production of hyperon (H) which has only one valence quark in common with the projectile P. In this case, the PFR is dominated by the hadronization product that contains this common valence quark, and the polarization of such H is determined completely by the points (I) and (II) mentioned above. E.g., $p+p \to \Sigma^- + X$, the common valence quark is d_v and, according to (I), d_v should have a large probability to be upwards polarized, if Σ^- is going left. Together with the wavefunction of Σ^-, this implies that the produced Σ^- has a probability of $5/6(1/6)C$ to be upwards (downwards) polarized, i.e. $P_H = (2/3)C$ for such Σ^-. Similarly, we obtain $P_H = (-1/3)C$ for such Ξ^- or Ξ^0 in pp-collisions; and so on. Since such H's dominate only at large x_F, we expect that the magnitudes of P_H increase with increasing x_F and the above mentioned results are their limits at $x_F \to 1$. All these are consistent with the data [4]. Furthermore, without any other input, we obtained, e.g.: (A) P_Λ in the PFR of $K^- + p \to \Lambda + X$ is large and is, in contrast to that in pp-collisions, positive in sign. (B) P_Λ in the PFR of $\pi^\pm + p \to \Lambda + X$ should be negative and the magnitude should be very small. (C) Not only hyperons but also the produced vector mesons are expected to be transversely polarized in the fragmentation region of hadron-hadron collisions. (D) Neither the contribution from hadronization to P_Λ nor that to A_N can be large. Presently, there are already data available for (A) and (B) [4], and they are *in agreement with these associations.* (D) is consistent with the results [5] of the recent SLD measurements of jet handedness at SLAC, which show that the spin dependence of hadronization is very little. (C) can be checked by future experiments.

In the second case, we considered the production of hyperon which has two valence quarks in common with the projectile and hence hyperons containing such common valence diquarks dominate the PFR. E.g., $p + p \to \Lambda + X$. We started [2] again from A_N for $p(\uparrow) + p \to \Lambda + X$ and recall that a significant A_N has been observed [4] in the PFR. This result was rather surprising since, according to the wavefunction of Λ, the common valence diquark $(u_v d_v)$ here has to be in the spin zero state thus cannot transfer the information of polarization to the produced Λ. An explanation is given in [2]. It has been pointed out [2] that, the production of the Λ containing the spin-0 $(u_v d_v)$ and a s_s is associated with the production of a K containing the remaining u_v^a of P and the $\bar{s}_s$. The information of polarization is carried by the u_v^a so that, according to (I), the produced K has a large probability to go left if P is upwards polarized. The Λ has therefore a large probability to go right since the transverse momentum should be compensated. In this way, the A_N data [4] has been reproduced. According to this, in unpolarized pp-collision, if the produced Λ is moving to the left, the associated K should mainly move to the right. Hence, according to (I), the u_v^a contained in this K should have a large probability to be downwards polarized. Since K has spin 0, the $\bar{s}_s$ should be upwards polarized. Hence, to get a negative P_Λ, we need only to assume that the sea quark-antiquark pair $s_s\bar{s}_s$ have opposite transverse spins. Under this assumption, the polarization of such Λ is completely determined by that of the remaining u_v^a. To test this, we did: First, we made a similar analysis for other hyperons. The obtained P_H's are all consistent with the available data [4]. Second, we made a quantitative estimation of P_Λ in $p+p \to \Lambda + X$ as a function of x_F. By taking the Λ's containing two, one or zero valence quark(s) of P into account, we obtained the result shown in Fig.1. Third, we derived a number of other consequences without any further input. E.g.: (α) The spin transfer D_{NN} in the PFR of $p(\uparrow) + p \to \Lambda + X$ should be positive and large for large x_F. (β) P_Λ in the PFR of $\Sigma^- + A \to \Lambda + X$ should be *negative* and much less significant than that in $p+p \to \Lambda + X$. (γ) Hyperon polarization in processes in which a vector meson is associatively produced should be very much different from that in processes in which a pseudoscalar meson is associatively produced. Presently, there are data available for the processes mentioned in (α) and (β) [4], and they are in agreement with the above expectations. (γ) is another characteristic feature of the model and can be used as a crisp test of the picture.

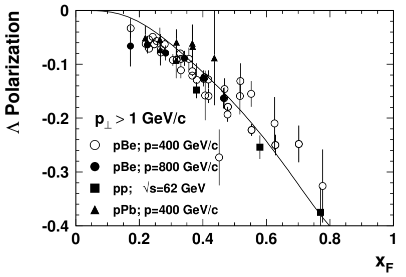

Fig.1: Calculated results for the polarization of Λ, P_Λ, as a function of x_F compared with the data [4]. See Ref.[1] for more detail.

1. Liang Zuo-tang and C. Boros, Phys. Rev. Lett. **79**, 3608 (1997).
2. C. Boros and Liang Zuo-tang, Phys. Rev. **D53**, R2279 (1996).
3. Liang Zuo-tang and C. Boros in preparation (1998).
4. For a review of the data, see: K. Heller, Proc.of the 12th Inter.Symp.on Spin Phys., Amsterdam, 1996; or A. Bravar *et al.*, these proceedings.
5. D. Buskulic *et al.*, Phys. Lett. **B374**, 319 (1996);
   K. Ackerstaff *et al.*, Euro. Phys. Jour. C**2**, 49 (1998).
6. K. Abe *et al.*,, Phys. Rev. Lett. **74**, 1512 (1995).