Spin-dependent forward scattering amplitude of Ω^-- hyperon on an unpolarized proton in Glauber eikonal approximation and the possibility of the constituent quark rescattering observation

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Abstract

For the Ω^--hyperon passing through matter the phenomena of spin rotation and oscillation has investigated quantitatively. Connection of these phenomena with constituent quark rescattering has been determined. It allows one to investigate constituent quark rescattering directly without background of a single scattering.

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1 Introduction

Picture of hadrons as being made of spatially separated constituent quarks is not new. It was considered on phenomenological grounds many times [1] since the pioneer works of Gell-Mann. After some period of misunderstanding it was clearly stated by Gell-Mann that "constituent" and "current" quarks are completely different objects. The constituent quarks or "valons" [2] appear as quasiparticles, that is as current quarks and surrounding them clouds of gluons and quark-antiquark pairs. Elastic scattering also can be understood in terms of the constituent quarks and Glauber eikonal approximation in which amplitude is expressed as series of the terms corresponding to the one-fold, two-fold... collisions of the constituent quarks. Items of the series is decreasing with the increasing of the multiplicity. Good test of the constituent quark model can represent experiment for investigating constituent quark rescattering. It turns out that observation of the hyperon spin oscillation and dihroism is exactly experiment above. It is necessary to stress that the effect of the spin oscillation holds only for the particles with the spin grater 1/2. In present work we show that the phenomenon of Ω^- spin rotation and oscillation depends only on the contribution of quark rescattering to the zero-angle elastic scattering amplitude i.e. first term of the Glauber series does not contribute to this effect.

2 The rotation and oscillation phenomenon of a Ω^--hyperon spin

In accordance with [3] the well-known formula [4]

$$\hat{n} = 1 + \frac{2\pi\rho}{k^2}\hat{F}(0)\ , \tag{1}$$

for the refraction index of a particle inside the matter can be applied to the non-zero spin particles. Here ρ is the density of scatterers in matter (the number of scatterers in 1 cm^3), k is the wave number of an incident particle. $\hat{F}(0)$ is the zero-angle elastic scattering amplitude, which is an operator in spin space of the incident particle. The dependence of the amplitude $\hat{F}(0)$ on the orientation of colliding particle spins gives rise to quasioptic effects (spin rotation, spin oscillation and dichroism) under the passage of a particle through the medium.

For particles with spins $S \geq 1$ [3] the rotation of a spin arises even in passing inside unpolarized targets.

Consider the propagation of Ω^--hyperon through the unpolarized medium in detail. Let the spin state of a particle being incident on a target is characterized by an initial spin wave function ψ_0. Then the spin wave function of the particle in the target can be written as:

$$\hat{\psi}(z) = \exp\{ik\hat{n}z\}\hat{\psi}_0\ . \tag{2}$$

If the target is unpolarized, the scattering amplitude at the zero angle is determined by hyperon spin properties only:

$$\hat{F}(0) = \frac{9F_{1/2}(0) - F_{3/2}(0)}{8} + \frac{F_{3/2}(0) - F_{1/2}(0)}{2}(\mathbf{Sn})^2\ , \tag{3}$$

where $\mathbf{n}$ is the direction of the incident particle momentum. F_m forward scattering amplitude in spin state with magnetic number m. It follows from (3), that the states with quantum numbers m and $-m$ are described by the same refraction indexes, however $n_{\pm 3/2} \neq n_{\pm 1/2}$. Thus this difference determines such effects as spin rotation and oscillation.

In general case the hyperon spin wave function at a medium entry can be written as:

$$\hat{\psi}_0 = \{a\, e^{-i\,\delta_{3/2}}, b\, e^{-i\,\delta_{1/2}}, c\, e^{-i\,\delta_{-1/2}}, d\, e^{-i\,\delta_{-3/2}}\}. \tag{4}$$

Using equations (1), (2), (3) it is possible to find the expressions for describing polarization vector, quadrupole (rank two) and octupole tensors of Ω^--hyperon as a function of a particle path length inside the target. In particular, for the polarization vector we have the following expressions:

$$\begin{aligned}
< S_x >= &\{2bc\cos(\delta_{1/2} - \delta_{-1/2})e^{-2n''_{1/2}kz} + \sqrt{3}\mathrm{ab} \\
&\times e^{-(n''_{3/2}+n''_{1/2})kz}\cos(\delta_{3/2} - \delta_{1/2} + (n'_{3/2} - n'_{1/2})kz) \\
&+\sqrt{3}\mathrm{cd}e^{-(n''_{3/2}+n''_{1/2})kz}\cos(\delta_{-1/2} - \delta_{-3/2} \\
&-(n'_{3/2} - n'_{1/2})kz)\}/|\psi|^2\ , \\
< S_y >= &\{-2\mathrm{bc}\sin(\delta_{1/2} - \delta_{-1/2})e^{-2n''_{1/2}kz} - \sqrt{3}\mathrm{ab} \\
&\times e^{-(n''_{3/2}+n''_{1/2})kz}\sin(\delta_{3/2} - \delta_{1/2} + (n'_{3/2} - n'_{1/2})kz) \\
&-\sqrt{3}\mathrm{cd}e^{-(n''_{3/2}+n''_{1/2})kz}\sin(\delta_{-1/2} - \delta_{-3/2} \\
&-(n'_{3/2} - n'_{1/2})kz)\}/|\psi|^2\ , \\
< S_z >= &\{\frac{3}{2}(a^2 - d^2)e^{-2\,n''_{3/2}\,kz} \\
&+\frac{1}{2}(b^2 - c^2)e^{-2\,n''_{1/2}\,kz}\}/|\psi|^2\ , \\
|\psi|^2 = &(a^2 + d^2)\,e^{-2\,n''_{3/2}\,kz} + (b^2 + c^2)\,e^{-2\,n''_{1/2}\,kz},
\end{aligned} \tag{5}$$

where z is the particle way length inside the medium. From these expressions it follows, that in general case the spin dynamics of Ω^- - hyperon is characterized by a superposition of two rotations in clockwise and counter-clockwise directions. Let's consider some particular cases. If the initial polarization vector is normal to the particle momentum so, the initial populations and phases of the states with the quantum numbers m are equal to the ones for the states with quantum numbers $-m$ then the components $< S_y >$, $< S_z >$ will remain zero during the whole time of particle penetration through the medium and $< S_x >$ oscillates. The components of quadrupole and octupole tensors of Ω^--hyperon oscillate too. If the initial polarization vector is directed at the acute angle to the momentum direction the polarization vector motion look like rotation. If the initial polarization vector is directed at the obtuse angle to the momentum direction the spin rotates in the opposite direction.

3 Amplitude of elastic scattering

To evaluate hyperon-proton scattering amplitude assume that the fundamental constituents making up the colliding hadrons in an elastic $\Omega^- p \to \Omega^- p$ scattering (presumably constituent quarks or valons) can scatter with an elementary amplitude $f_{ij}(s,t)$, where the subscripts refer to different flavors [5], s is a squared energy of colliding quarks in their center-of-mass frame, t is the square of the 4-impulse transferred. At the elastic small angle scattering t is expressed through the transverse transferred momentum $\mathbf{q}$: $t = -q^2$.In accordance with the eikonal model the hyperon-proton scattering amplitude is written down as [6]:

$$F_m(\mathbf{q}) = \frac{i}{2\pi}\int d^2\mathbf{b} e^{i\mathbf{qb}} < m \mid 1 - \prod_{i,j=1}^{3}(1 - \Gamma_{ij}(\mathbf{b} - \boldsymbol{\eta}_i + \boldsymbol{\eta}'_j)) \mid m > = \frac{i}{2\pi}\int d^2\mathbf{b} e^{i\mathbf{qb}} \int d^2\boldsymbol{\eta}_1 d^2\boldsymbol{\eta}_2 \times d^2\boldsymbol{\eta}'_1 d^2\boldsymbol{\eta}'_2 \wp_m(\boldsymbol{\eta}_1,\boldsymbol{\eta}_2)\wp'(\boldsymbol{\eta}'_1,\boldsymbol{\eta}'_2)(1 - \prod_{i,j=1}^{3}(1 - \Gamma_{ij}(\mathbf{b} - \boldsymbol{\eta}_i + \boldsymbol{\eta}'_j))) \ , \quad (6)$$

where $\boldsymbol{\eta}_i$ ($\boldsymbol{\eta}'_i$) is quarks transverse coordinates in a hyperon (proton) relative to the hadron center-of-mass: $\boldsymbol{\eta}_3 = -\boldsymbol{\eta}_2 - \boldsymbol{\eta}_1$, $\boldsymbol{\eta}'_3 = -\boldsymbol{\eta}'_2 - \boldsymbol{\eta}'_1$. $\wp_m(\boldsymbol{\eta}_1,\boldsymbol{\eta}_2)$, $\wp'(\boldsymbol{\eta}'_1,\boldsymbol{\eta}'_2)$ are quark distribution functions over transverse coordinates in a hyperon and a proton respectively, m is the projection of a Ω^--hyperon spin, $\Gamma_{ij}(\mathbf{b})$ is the profile - function connected with the quark scattering amplitude $f_{ij}(\mathbf{q})$ by means of the following relation:

$$\Gamma_{ij}(\mathbf{b}) = \frac{1}{2\pi i}\int f_{ij}(\mathbf{q}) e^{-i\mathbf{qb}} d^2\mathbf{q}. \quad (7)$$

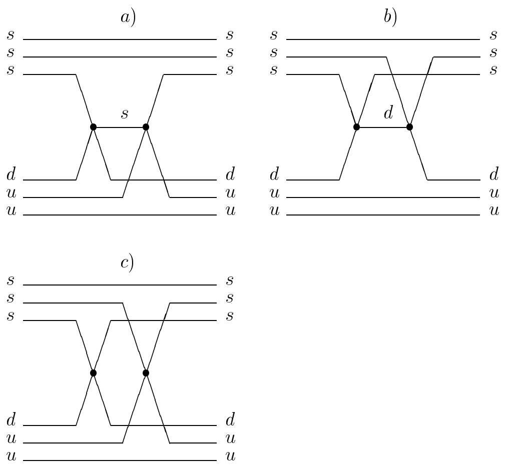

Figure 1: Diagrams of the double quark scattering contribution to the $\Omega^- - p$ elastic scattering.

The amplitude $F_m(\mathbf{q})$ is normalized by the condition :

$$\frac{d\sigma}{dt}^m = \mid F_m(q) \mid^2, \qquad \sigma_{tot}^m = 4\pi Im F_m(0) \ .$$

In such a normalization the amplitude of scattering is invariant relative to the Lorentz transform along the incident particle momentum direction. It can be obtained from the usual amplitude used in the formula (1) through division by a wave number k (small-angle scattering is meant). We shall not distinguish u and d quarks, as a result the single scattering amplitude $f(q)$ of s-quark on u or d quarks should be considered. The expression (6) for the scattering amplitude can be rewritten as:

$$F_m(\mathbf{q}) = \frac{i}{2\pi}\int d^2\mathbf{b} e^{i\mathbf{qb}}(1 - \gamma_m(\mathbf{b})); \quad (8)$$

$$\gamma_m(\mathbf{b}) = < m \mid 1 - \sum_{ij}\Gamma_{ij} + \frac{1}{2!}{\sum_{\substack{ij\\kl}}}' \Gamma_{ij}\Gamma_{kl} - \frac{1}{3!}{\sum_{\substack{ijk\\lpn}}}' \Gamma_{ij}\Gamma_{kl}\Gamma_{pn} + \ldots \mid m > . \quad (9)$$

The prime in the above sum means a lack of terms with pairwise equal indexes in it, for example $i = k$ and $j = l$. We limit ourself by the exact account of double collisions and carry factorization of the equation (9):

$$\gamma_m(\mathbf{b}) \approx 1 - < m \mid \sum_{i,j}\Gamma_{ij} \mid m > + \frac{1}{2!} < m \mid {\sum_{\substack{ij\\kl}}}' \Gamma_{ij}$$

$$\times\Gamma_{kl} \mid m> -\frac{1}{3!} < m \mid \sum_{\substack{ij\\kl}}{}' \Gamma_{ij}\Gamma_{kl} \mid m>$$

$$\times < m \mid \sum_{pn} \Gamma_{pn} \mid m> + \frac{1}{4!} < m \mid \sum_{\substack{ij\\kl}}{}' \Gamma_{ij}\Gamma_{kl} \mid m>^2$$

$$-... = ch\{\Omega'_m(\mathbf{b})\} - \Omega_m(\mathbf{b})\frac{sh\{\Omega'_m(\mathbf{b})\}}{\Omega'_m(\mathbf{b})}, \quad (10)$$

where

$$\Omega_m(\mathbf{b}) \equiv < m \mid \sum_{i,j} \Gamma_{ij} \mid m> = \frac{9}{2\pi i}\int f(\mathbf{q})G_m(\mathbf{q}) \times G'(\mathbf{q})e^{-i\mathbf{q}\mathbf{b}}d^2\mathbf{q}\ ,$$

$$(\Omega'_m(\mathbf{b}))^2 \equiv < m \mid \sum_{\substack{ij\\kl}}{}' \Gamma_{ij}\Gamma_{kl} \mid m> = -\frac{18}{4\pi^2}\int f(\mathbf{q}) \times f(\mathbf{q}')[G'(\mathbf{q}+\mathbf{q}')G_m(\mathbf{q},\mathbf{q}') + G'(\mathbf{q},\mathbf{q}')G_m(\mathbf{q}+\mathbf{q}') + 2G_m(\mathbf{q},\mathbf{q}')G'(\mathbf{q},\mathbf{q}')]e^{-i(\mathbf{q}+\mathbf{q}')\mathbf{b}}d^2\mathbf{q}d^2\mathbf{q}'. \quad (11)$$

The factorization (10) is minimal, in the sense that the each item in equation (9) is divided in the smallest number of multiplicands. Another factorization is offered in [7]:

$$\gamma_m(\mathbf{b}) \approx \exp\left(-\Omega_m(\mathbf{b}) + \frac{1}{2}\left(\Omega'_m(\mathbf{b})\right)^2 - \frac{1}{2}\left(\Omega_m(\mathbf{b})\right)^2\right). \quad (12)$$

The total factorization of a series (9) corresponds to

$$\gamma_m(\mathbf{b}) \approx \exp\left(-\Omega_m(\mathbf{b})\right) \quad (13)$$

i.e. to the optical limit. Form factors found in the non-relativistic quark model [8] have the form:

$$G_{\substack{3/2\\1/2}}(\mathbf{q},\mathbf{q}') = \int \wp_{\substack{3/2\\1/2}}(\boldsymbol{\eta}_1,\boldsymbol{\eta}_2)\exp\left(i\mathbf{q}\boldsymbol{\eta}_1 + i\mathbf{q}'\boldsymbol{\eta}_2\right) \times d^2\boldsymbol{\eta}_1 d^2\boldsymbol{\eta}_2 = \exp\left(\frac{(-q^2 - q'^2 + \mathbf{q}\mathbf{q}')R^2}{6}\right) \times\left[1 \mp \frac{Q}{12}(q^2 + q'^2 - \mathbf{q}\mathbf{q}')\right], \quad (14)$$

where $Q = 8\times 0.068R^2/\sqrt{30}$ is the quadrupole moment of Ω^--hyperon. In the considered model of Ω^--hyperon the difference between form factors for the states with the $\pm 3/2$ and $\pm 1/2$ spin projections is mainly determined mainly by the impurity of $|^4\ D>$ state, as well as by the quadrupole moment. $G'(\mathbf{q},\mathbf{q}')$ is a same quantity for a proton, $G'(\mathbf{q}) = G'(\mathbf{q},0)$, $G_m(\mathbf{q}) = G_m(\mathbf{q},0)$. Let us show that the single collision contribution to the scattering amplitude at the zero angle does not depend on m: $F_m^{(1)}(0) = \frac{i}{2\pi}\int d^2\mathbf{b}\Omega_m(\mathbf{b}) = 9f(0)G_m(0)G'(0) = 9f(0)$. Therefore the single scattering falls out from the difference of forward scattering amplitudes for the states with different m.

For further calculations the quark scattering amplitude can be taken in the form:

$$f(\mathbf{q}) = f(0)\exp\left(-aq^2/2\right), \qquad f(0) = \frac{(i+0.2)\sigma_{qs}}{4\pi}. \quad (15)$$

$\sigma_{qs} = 3.2\ mb$ is the cross section of the s-quark - u,d-quark scattering, $a = 0.8\ Gev^{-2}$ [5], for the $292.4\ Gev$ hyperon energy in the proton rest frame ($\sqrt{s} = 23.5\ Gev$). Substituting the form factors (14) and amplitude (15) to the equations (11) it is possible to evaluate $\Omega_{\substack{3/2\\1/2}}(\mathbf{b})$ and $\Omega'^2_{\substack{3/2\\1/2}}(\mathbf{b})$.

4 Inelastic corrections to double scattering

Partonic structure of the constituent quark is a natural bridge between constituent quarks in the bound-state problem of the hadrons and the partons as probed in deep-inelastic scattering. For the constituent quarks besides an elastic scattering the inelastic one (with excitation one or both quarks) exists. It means that under collision process quark can transit to an excited state, that afterwards leads to the production of new particles. But if the excited quark strikes once more it can lose excitation and makes the contribution to the elastic hadron scattering amplitude. The similar effects were considered for nuclei collision [9], [10] on a nucleon level, and in the problem of "color transparency" [11], [12].

Formula (11) describes double scattering of three kinds shown at figure 1. We should add the diagrams of figure 2. to the diagrams of figure 1. As a result the equation (11) becomes:

$$(\Omega'_m(\mathbf{b}))^2 \equiv -\frac{18}{4\pi^2}\{\int (f(\mathbf{q})f(\mathbf{q}') + \sum_{n\neq 0} f_{0n}(\mathbf{q}) \times f_{n0}(\mathbf{q}'))(G'(\mathbf{q}+\mathbf{q}')G_m(\mathbf{q},\mathbf{q}') + G'(\mathbf{q},\mathbf{q}') \times G_m(\mathbf{q}+\mathbf{q}'))e^{-i(\mathbf{q}+\mathbf{q}')\mathbf{b}}d^2\mathbf{q}d^2\mathbf{q}' + 2\int f(\mathbf{q})f(\mathbf{q}') \times G_m(\mathbf{q},\mathbf{q}')G'(\mathbf{q},\mathbf{q}')e^{-i(\mathbf{q}+\mathbf{q}')\mathbf{b}}d^2\mathbf{q}d^2\mathbf{q}'\}. \quad (16)$$

The amplitude $f_{n0}(q)$ $\ (f_{00}(q) \equiv f(q))$ represents the quark scattering amplitude corresponding to the one quark transition to the n-th excited state and $f_{0n}(q)$ is amplitude of the back transition from the excited state to the unexcited one. Let's consider the contribution of this inelastic process to the elastic forward $\Omega^- p$ scattering amplitude taking into account only double collisions:

$$F_m^{(2)}(0) = \frac{i}{2\pi}\int d^2\mathbf{b}\frac{1}{2}\Omega_m'^2(\mathbf{b}) = \frac{-18i}{4\pi}\Bigg[\int\sum_{n=0} f_{0n}(\mathbf{q})$$

$$\times f_{n0}(-\mathbf{q})\Big(G'(0)G_m(\mathbf{q},-\mathbf{q}) + G'(\mathbf{q},-\mathbf{q})G_m(0)\Big)d^2\mathbf{q}$$

$$+2\int f(\mathbf{q})f(\mathbf{q}')G'(\mathbf{q},-\mathbf{q})G_m(\mathbf{q},-\mathbf{q})d^2\mathbf{q}\Bigg]$$

$$\approx \frac{-18\imath}{4\pi}\Bigg[\sum_{n=0} f_{0n}(0)f_{n0}(0)\int\Big(G'(0)G_m(\mathbf{q},-\mathbf{q})$$

$$+G'(\mathbf{q},-\mathbf{q})G_m(0)\Big)d^2\mathbf{q} + 2f(0)f(0)$$

$$\times\int G'(\mathbf{q},-\mathbf{q})G_m(\mathbf{q},-\mathbf{q})d^2\mathbf{q}\Bigg]. \quad (17)$$

Under derivation of equation (17) we assume that the form factors of a proton and hyperon are characterized by sharper $q-$ dependence in comparison with the amplitudes $f_{0n}(\mathbf{q})$ taken out of the integral. So, the inelastic corrections are mainly determined by the amplitude of inelastic quark scattering at zero angle.

Let's consider a model which follows from the naive concept of composite particles, i.e. from assumption, that the constituent quark consists of elementary constituents (partons). Partonic picture of hadron collision is not fully invariant under Lorentz transforms [13]. We use the centrer of mass frame.

Among all partons there are N active partons, which can elastically scatter each other under the quark collision. The active partons is considered to be slow, and carry a small part of hadron momentum [13]. If the quark excitation energy is about a pion mass m_π, then wave function of excited state of quark depends on time as $\sim e^{im_\pi t}$. One oscillation is made on length $1\ /m_\pi$ in a quark rest frame, but in a laboratory frame this length increases in γ times (γ is Lorentz - factor of a particle) and becomes much greater than the hadron size $1/m_N$. It allows us to neglect the evolution of quark inner degrees freedom during the collision. That is a usual condition of Glauber approximation applicability. A peculiarity of the partonic level compared to the constituent quark level is the fluctuating number of the active partons in the constituent quark. We may write the zero-angle quark scattering amplitude as:

$$\hat{f}(0) = \frac{i}{2\pi}\int d^2\mathbf{b}\Gamma(\hat{N},\hat{N}',\mathbf{b}),$$

$\Gamma(\hat{N},\hat{N}',\mathbf{b})$

$$= -\sum_{k=1}^{\hat{N}*\hat{N}'}\frac{\hat{N}\hat{N}'(\hat{N}\hat{N}'-1)...(\hat{N}\hat{N}'-k+1)}{k!}$$

$$\times\left(-\frac{3\mathrm{f}_p}{2ir_q^2}\exp\left(-\frac{3b^2}{4r_q^2}\right)\right)^k$$

$$= 1-\left(1-\frac{3\mathrm{f}_p}{2ir_q^2}\exp\left(-\frac{3b^2}{4r_q^2}\right)\right)^{\hat{N}\hat{N}'}, \quad (18)$$

where $r_q \approx \frac{3}{2}a$ is mean square radius of constituent quark and f_p is amplitude of the parton elastic scattering. The amplitude $\hat{f}(0)$ and profile-function $\Gamma(\mathbf{b})$ contain operators of the active parton number $\hat{N}$ and $\hat{N}'$ in a hyperon and proton quarks, respectively. Because b-picture of quark collision is not important here we simplify it using single-scattering eikonal function in degree of collision multiplicity k and then multiply it by the number of the k-multiple terms. For quark elastic scattering amplitude we have:

$$f(0) = <0,0\mid\hat{f}(0)\mid 0,0> = \frac{i}{2\pi}\sum_{N,N'}P(N)P(N')$$

$$\times\int\Gamma(N,N',b)d^2b. \quad (19)$$

$\mid 0,0> \equiv \mid 0>\mid 0>$, $\mid 0>$ is unexcited state of the constituent quark, $P(N)$ is probability to find N active partons in the constituent quark. Now let's consider the magnitude of $<0,0\mid\hat{f}(0)\mid 0><0\mid\hat{f}(0)\mid 0,0>$, containing the contribution of inelastic corrections, which is $\sum_{n\neq 0}<0,0\mid\hat{f}(0)\mid n,0><0,n\mid\hat{f}(0)\mid 0,0>$. The direct evaluation gives:

$$<0,0\mid\hat{f}(0)\mid 0><0\mid\hat{f}(0)\mid 0,0> = \frac{-1}{4\pi^2}\sum_{N,N',N''}$$

$$P(N)P(N')P(N'')\int d^2\mathbf{b}d^2\mathbf{b}'\Gamma(N,N',b)$$

$$\times\Gamma(N,N'',b'). \quad (20)$$

By reversing equation (19) it is possible to find f_p through $f(0)$ and substituting it in (20) find $<0,0\mid\hat{f}(0)\mid 0><0\mid\hat{f}(0)\mid 0,0>$. Double quark scattering with inelastic shadowing can be roughly found by using $<0,0\mid\hat{f}(0)\mid 0><0\mid\hat{f}(0)\mid 0,0>$ in two first items in equation (11) instead of $f^2(0)$. Such a program was realized in our numerical calculations.

5 Results and discussion

We now substitute $\Omega'^2_{\substack{3/2\\1/2}}(\mathbf{b})$ and $\Omega_{\substack{3/2\\1/2}}(\mathbf{b})$ to the one of equations (10), (12), (13) for $\gamma_m(b)$ and through numeri-

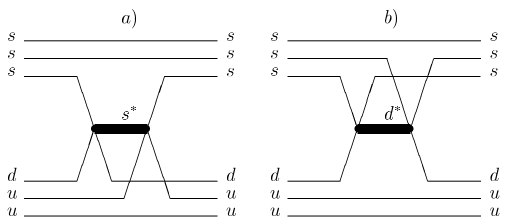

Figure 2: Diagrams of the inelastic corrections to the double quark scattering. * denotes excited quark state.

cal integration of (8) find the difference between the forward elastic $\Omega^- - p$ scattering amplitudes corresponding to hyperon spin projections $\pm$ 1/2 and $\pm$ 3/2. Then we are able to obtain the magnitude of dichroism and spin oscillation phase to be interested in. For a determinacy we shall make the calculations for the meter hydrogen target of 0.0675 g/cm^3 density. The value of a quadrupole moment $Q = 2 \times 10^{-2}(fm)^2$ we shall take from work [8]. The mean squared radiuses of a hyperon and proton we shall accept as 0.35 fermi squared [8] and 0.65 [5] respectively. Let us discuss the dependence of the effect i.e. dependence of the amplitude difference $F_{3/2}(0) - F_{1/2}(0)$ on the hyperon energy. In accordance with the Regge [14] and parton [13] theories the quantity a, proportional to the sum of mean squared radiuses of colliding quarks, grows as $ln(s)$, so, we can write roughly:

$$a(s^q) = a(s_0^q)\left(1 + ln\left(\frac{s^q}{s_0^q}\right)\right). \tag{21}$$

$\sqrt{s^q}$ is the energy of colliding quarks in a system of their center-of-mass, a is the known magnitude of $a(s^q)$, for a given s_0^q . At high energies $\frac{s^q}{s_0^q} = \frac{s}{s_0}$, where s is the squared energy of colliding hadrons in a center-of-mass frame. We take $\sqrt{s_0} = 23.5\ Gev$) As for the quarks scattering cross section σ_{qs}, used in (15), it is possible to write from the Regge theory :

$$\sigma_{qs}(s^q) = \sigma_{qs}(s_0^q)\left(\frac{s^q}{s_0^q}\right)^{\Delta}. \tag{22}$$

We have taken the value $\Delta = 0.125$ from $p-p$ scattering data [15]. The ratio of the real part of quark scattering amplitude to the imaginary one is considered to be value as at $\sqrt{s} = 23.5\ Gev$ i.e. 0.2. The dependence of phase oscillation (it is approximately equaled to a rotation angle) and dichroism on hyperon energy are shown on figures 3,4 respectively. ϕ is the phase of oscillations of a hyperon spin:

$$\phi(z) = 2\pi\rho Re(F_{3/2}(0) - F_{1/2}(0))z, \tag{23}$$

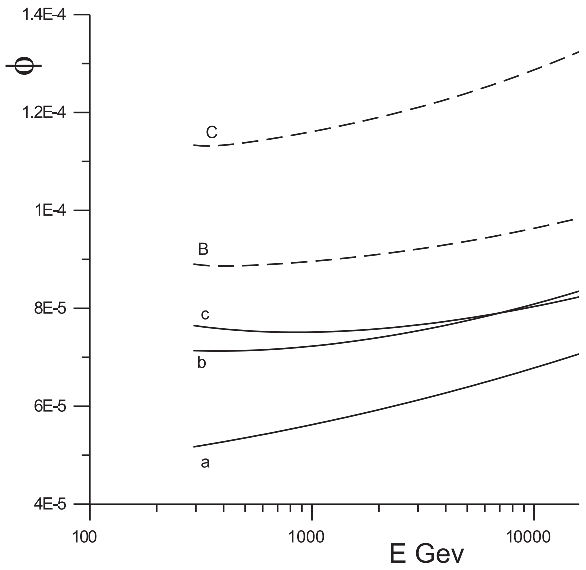

Figure 3: Energy dependence of Ω^--hyperon spin oscillation phase (rotation angle) in meter hydrogen target.

and

$$A(z) = \frac{I_{1/2}(z) - I_{3/2}(z)}{I_{3/2}(z) + I_{1/2}(z)} = 2\pi\rho Im(F_{3/2}(0) - F_{1/2}(0))z \tag{24}$$

describes dichroism. $I_m(z)$ is the intensity of hyperons with the spin projection m on the depth z , if the incident beam is unpolarized. Curve (a) correspounds the optical limit, i.e. structureless hadrons and lies considerably lower then the curves (b),(c) suggesting constituent quark model. The inelastic corrections (curve (B), (C)) evaluated for Poisson distribution for the number of active partons in constituent quarks. Mean active parton number in constituen quark was taken to be equal 1. If mean the number of active partons increases the inelastic corrections decreases. The difference between (b) and (c) as well as (B) and (C) arises due to different manner of three- and more- multiple collision account.

For a hyperon with energy 292.4 Gev ($\sqrt{s} = 23.5\ Gev$) in a meter hydrogen target dichroism $\approx 1.4 \times 10^{-4}$ for the structureless hadrons and $2.0 - 2.1 \times 10^{-4}$ for the hadrons built from the constituent quarks. Oscillation phase (rotation angle) is $\approx 5.2 \times 10^{-5}$ in the first case and $\approx 7.1 - 7.7 \times 10^{-5}$ in the second. There is good reason to believe that they will be greater due to inelastic corrections. We may use any light nucleus target instead of hydrogen one. For light nuclei forward scattering amplitude is proportional to the mass number, so the value of rotation angle and dichroism may be obtained by using nucleon density in the target chosen as ρ in equations

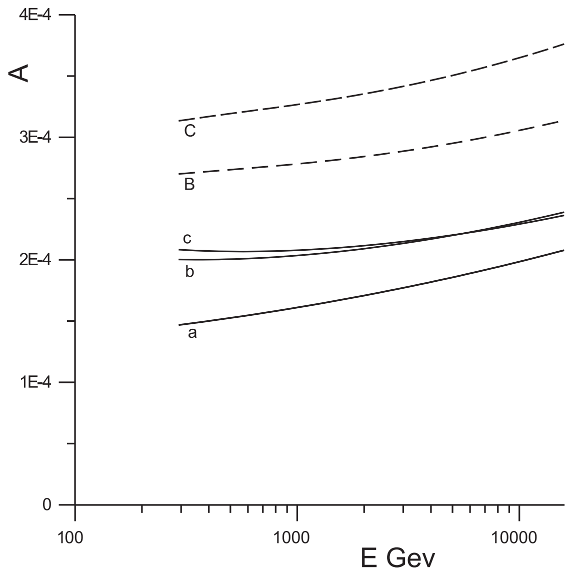

Figure 4: Energy dependence of Ω^--hyperon spin dichroism in meter hydrogen target.

(23), (24). In a meter carbon target of 2.2 g/cm^3 density dichroism $\approx 7.5 \times 10^{-3}$ and rotation angle $\approx 2.5 \times 10^{-3}$. For measuring rotation angle of the Ω^--hyperon polarization procedure used in [16] is applicable although higher statistics is needed.

6 Conclusion

Summing up it is possible to tell that the spin oscillations and dichroism, of high-energy particles with a spin $S \geq 1$ passing through matter allow one to observe constituent quark rescattering directly in a broad energy range avoiding a background of single scattering. An importan point is that the effect increases the energy increases.

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