The effect of spin oscillation of relativistic particles passing through substance and the possibility of the constituent quark rescattering observation at Ω^--hyperon - proton collision

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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 quark rescattering directly without background of a single scattering.

1. Introduction

The research of spin effects in collisions of high energy particles gives important information about their fundamental properties : the quark-gluon interaction, particle wave function, the chiral symmetry violation mechanism, etc (Yndurain 1993). In the local quantum field theory there are two fundamental principles: unitarity and analyticity. It is known that unitarity links the imaginary part of the forward scattering amplitude with the total cross section for colliding particles. In general case the total cross section depends on a spin orientation and can be measured. The dispersion relations between real and imaginary parts of the forward scattering amplitude can be obtained from analyticity. By measuring imaginary and real parts of a zero angle scattering amplitude in a wide energy range we get a possibility to check up unitarity and analicity principles. As the direct measurements of the real part of the forward scattering amplitude in ordinary scattering experiments are practically impossible, it is necessary to measure the differential cross section and other observables for small-angle range of the coulomb-nuclear interference with subsequent extrapolation of data to the zero angle (Akchurin *et al* 1993). There is, however, a possibility of the direct measurement of the real part of the forward scattering amplitude (Baryshevsky 1992, 1993). It was shown that under penetration of a particle with $S \geq 1$ spin through the medium two effects: spin rotation and oscillation appear. The magnitude of these effects is determined by the real part of the spin-dependent forward scattering amplitude. The unic peculiarity of the spin oscillation phenomenon is that the spin oscillation effect does not decrease with energy increasing, but even gains (Baryshevsky 1993). This phenomenon was analyzed for a deuteron (Baryshevsky 1993). It was shown, that the spin dependent part of the forward scattering amplitude measured with the help of spin oscillation phenomenon is determined only by effects of nucleon rescattering and gives the information about the nucleon interaction at small distances.

In the present work we consider the phenomena of oscillation and rotation of Ω^--hyperon spin. For description of this effect we use the Glauber eikonal approximation (Czyz and Maximon 1969). It explore the idea that the matter densities of the colliding particles determine the small angle scattering cross section and follows from the geometry and probability calculus. It turns out that the effects of the spin rotation, oscillation and dichroism is sensitive to the hadron inner structure i.e. allow to check the hypotheses of the constituent quarks. Picture of hadrons as being made of spatially separated constituent quarks is not new. It was considered on phenomenological grounds many times (Anisovich *et al* 1985) since the pioneer works of Gell-Mann 1964. 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" (Hwa 1980) appear as quasiparticles, that is as current quarks and surrounding them clouds of gluons and quark-antiquark pairs. Spin-dependent part of the zero angle elastic scattering amplitude of Ω^--hyperon at an unpolarized proton measured with the help of spin oscillation and dichroism is determined by the shadowing effects which strongly depends on the structure of hadrons.

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

In accordance with Baryshevsky 1992,1993 the well-known formula (Lax 1951)

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

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 (Baryshevsky 1992,1993).

For particles with spins $S \geq 1$ (Baryshevsky 1992,1993) 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:

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

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 $F_{3/2}(0)$ and $F_{1/2}(0)$ correspond to zero angle scattering amplitudes for the Ω^- hyperon with the spin projection $S_z = 3/2$ and $S_z = 1/2$ to the direction $\mathbf{n}$ of the incident particle momentum.

Equation (3) contains only term with square-law dependence of spin (we consider T-invariant interactions, therefore the odd powers of spin in the amplitude should be absent). Denoting magnetic quantum number through m we obtain from equations (1),(3):

$$n_m = 1 + \frac{2\pi\rho}{k^2}F_m(0) \ , \tag{4}$$

$$n_m = n'_m + \mathrm{i}n''_m \ ,$$

where n'_m, n''_m are the real and imaginary parts of the refraction index for the particle in an eigenstate with spin operator projection $S_z = m$.

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:

$$\hat{\psi}_0 = \{\mathrm{a}\,\mathrm{e}^{-\mathrm{i}\,\delta_{3/2}}, \mathrm{b}\,\mathrm{e}^{-\mathrm{i}\,\delta_{1/2}}, \mathrm{c}\,\mathrm{e}^{-\mathrm{i}\,\delta_{-1/2}}, \mathrm{d}\,\mathrm{e}^{-\mathrm{i}\,\delta_{-3/2}}\}. \tag{5}$$

Using equations (2),(4),(5), 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 (see appendix). In particular, for the polarization vector we have the following expressions:

$$< S_x >= \{2\mathrm{bc}\cos(\delta_{1/2} - \delta_{-1/2})\mathrm{e}^{-2n''_{1/2}kz} + \sqrt{3}\mathrm{abe}^{-(n''_{3/2}+n''_{1/2})kz} \times \cos(\delta_{3/2} - \delta_{1/2} + (n'_{3/2} - n'_{1/2})kz) + \sqrt{3}\mathrm{cd} \times \mathrm{e}^{-(n''_{3/2}+n''_{1/2})kz}\cos(\delta_{-1/2} - \delta_{-3/2} - (n'_{3/2} - n'_{1/2})kz)\}/|\psi|^2 \ ,$$

$$< S_y >= \{-2\mathrm{bc}\sin(\delta_{1/2} - \delta_{-1/2})\mathrm{e}^{-2n''_{1/2}kz} - \sqrt{3}\mathrm{abe}^{-(n''_{3/2}+n''_{1/2})kz} \times \sin(\delta_{3/2} - \delta_{1/2} + (n'_{3/2} - n'_{1/2})kz) - \sqrt{3}\mathrm{cd} \times \mathrm{e}^{-(n''_{3/2}+n''_{1/2})kz}\sin(\delta_{-1/2} - \delta_{-3/2} - (n'_{3/2} - n'_{1/2})kz)\}/|\psi|^2 \ , \quad (6)$$

$$< S_z >= \{\tfrac{3}{2}(\mathrm{a}^2 - \mathrm{d}^2)\mathrm{e}^{-2\,n''_{3/2}\,kz} + \tfrac{1}{2}(\mathrm{b}^2 - \mathrm{c}^2)\mathrm{e}^{-2\,n''_{1/2}\,kz}\}/|\psi|^2 \ ,$$

$$|\psi|^2 = (\mathrm{a}^2 + \mathrm{d}^2)\,\mathrm{e}^{-2\,n''_{3/2}\,kz} + (\mathrm{b}^2 + \mathrm{c}^2)\,\mathrm{e}^{-2\,n''_{1/2}\,kz},$$

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. In the appendix it is shown, that 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

Let the Ω^--hyperon passes through a hydrogen target. As it has been shown above the phenomenon of spin oscillations is determined by the forward scattering amplitude of Ω^- on an unpolarized particle. 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 (Furget *et al* 1990), 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 (Czyz and Maximon 1969):

$$F_m(\mathbf{q}) = \frac{\mathrm{i}}{2\pi}\int \mathrm{d}^2\mathbf{b}\mathrm{e}^{\mathrm{i}\mathbf{qb}} < m \mid 1 - \prod_{i,j=1}^{3}(1-\Gamma_{ij}(\mathbf{b}-\vec{\eta}_i+\vec{\eta}'_j)) \mid m >$$

$$= \frac{\mathrm{i}}{2\pi}\int \mathrm{d}^2\mathbf{b}\mathrm{e}^{\mathrm{i}\mathbf{qb}}\int \mathrm{d}^2\vec{\eta}_1\mathrm{d}^2\vec{\eta}_2\mathrm{d}^2\vec{\eta}'_1\mathrm{d}^2\vec{\eta}'_2\wp_m(\vec{\eta}_1,\vec{\eta}_2)\wp'(\vec{\eta}'_1,\vec{\eta}'_2)$$

$$\times(1-\prod_{i,j=1}^{3}(1-\Gamma_{ij}(\mathbf{b}-\vec{\eta}_i+\vec{\eta}'_j)))\ , \qquad (7)$$

where $\vec{\eta}_i$ $(\vec{\eta}'_i)$ is quarks transverse coordinates in a hyperon (proton) relative to the hadron center-of-mass: $\vec{\eta}_3 = -\vec{\eta}_2 - \vec{\eta}_1$, $\vec{\eta}'_3 = -\vec{\eta}'_2 - \vec{\eta}'_1$. $\wp_m(\vec{\eta}_1,\vec{\eta}_2)$, $\wp'(\vec{\eta}'_1,\vec{\eta}'_2)$ 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:

$$\Gamma_{ij}(\mathbf{b}) = \frac{1}{2\pi\mathrm{i}}\int f_{ij}(\mathbf{q})\mathrm{e}^{-\mathrm{i}\mathbf{qb}}\mathrm{d}^2\mathbf{q}. \qquad (8)$$

The amplitude $F_m(\mathbf{q})$ is normalized by the condition (Furget *et al* 1990):

$$\frac{d\sigma^m}{dt} = \pi \mid F_m(q) \mid^2, \qquad \sigma^m_{tot} = 4\pi Im F_m(0)\ . \qquad (9)$$

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). Note that the quark distribution function over transverse coordinates is also invariant under this transforms. This allows us to calculate it in the particle rest frame, by integrating the ordinary distribution function $\Re_m(\mathbf{r}_1,\mathbf{r}_2)$ over all z_i coordinates, where $\mathbf{r}_i \equiv (\vec{\eta}_i, z_i)$ and z-axes parallel to the incident particle momentum direction.

For simplicity we consider the amplitude quark scattering as spinless, therefore the hyperon spin dependence is reduced to the spin dependence of quark distribution function $\wp_m(\vec{\eta}_1,\vec{\eta}_2)$. Let's show, however, that for an unpolarized proton the contribution of single quark scattering process to the $F_m(0)$ amplitude does not depend on a spin state of a hyperon m even in the case of spindependent quark scattering amplitude. Let's rewrite formula (7) for single scattering but taking into account quark spins:

$$F^{(1)}_m(0) = \frac{\mathrm{i}}{2\pi}\int \mathrm{d}^2\mathbf{b}\int \mathrm{d}^2\vec{\eta}_1..\mathrm{d}^2\vec{\eta}_3\mathrm{d}^2\vec{\eta}'_1..\mathrm{d}^2\vec{\eta}'_3\ \mathrm{Tr}_{\substack{1'2'3'\\123}}[\wp'(\vec{\eta}'_1,\vec{\eta}'_2,\vec{\eta}'_3)\wp_m(\vec{\eta}_1,\vec{\eta}_2,\vec{\eta}_3)$$

$$\times\sum_{i,j=1}^{3}\Gamma_{ij}(\mathbf{b}-\vec{\eta}_i+\vec{\eta}'_j)] = \frac{\mathrm{i}}{2\pi}\sum_{i,j=1}^{3}\int \mathrm{d}^2\mathbf{b}\int \mathrm{d}^2\vec{\eta}_i\mathrm{d}^2\vec{\eta}'_j\ \mathrm{Tr}_{\substack{i\\j}}[\wp_m(i,\vec{\eta}_i)$$

$$\times\wp'(j,\vec{\eta}'_j)\Gamma_{ij}(\mathbf{b}-\vec{\eta}_i+\vec{\eta}'_j)] = \sum_{i,j=1}^{3}\mathrm{Tr}_{\substack{i\\j}}[\wp_m(i)\wp'(j)f_{ij}(0)]. \qquad (10)$$

The profile-function $\Gamma_{ij}(\mathbf{b})$ and, consequently the amplitude $f_{ij}(\mathbf{q})$ are the operators in the quark spin space. $\wp'(\vec{\eta}_1', \vec{\eta}_2', \vec{\eta}_3')$ and $\wp_m(\vec{\eta}_1, \vec{\eta}_2, \vec{\eta}_3)$ represent simultaneously distribution functions of quarks over transverse coordinates and spin density matrixes of quarks in a unpolarized proton and hyperon with a projection of a spin m respectively. To consider all quarks in the same way we have formally included the integration over third quark coordinates by putting $\wp_m(\vec{\eta}_1, \vec{\eta}_2, \vec{\eta}_3) = \wp_m(\vec{\eta}_1, \vec{\eta}_2)\delta(\vec{\eta}_1+\vec{\eta}_2+\vec{\eta}_3)$. The forward scattering amplitude in case of P,T-conservation has the following form:

$$f_{ij}(0) = f'_{ij} + f''_{ij}\vec{\sigma}_i\vec{\sigma}'_j + f'''_{ij}(\vec{\sigma}_i\mathbf{n})(\vec{\sigma}'_j\mathbf{n}), \tag{11}$$

where $\vec{\sigma}_i$ and $\vec{\sigma}'_j$ are the spin matrixes of hyperon and proton quarks, respectively. The vector $\mathbf{n}$ determines the direction of a hyperon motion and we assume it to coincide with the direction of hyperons quark motion. The averaging $\vec{\sigma}'_j$ over a spin density matrix of quark in an unpolarized proton gives zero. Taking into account that $Sp_i[\wp_m(i)) = 1$ and $Sp_j[\wp'_m(j)] = 1$ we obtain that

$$F_m^{(1)}(0) = \sum_{i,j=1}^{3} f'_{ij} \ ,$$

and consequently does not depend on the spin state of a hyperon. Everywhere further we consider quarks as spinless objects. 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.

4. The quark transverse coordinates distribution function

As it has been already mentioned the elastic forward scattering amplitude of Ω^- on an unpolarized proton depends on a spin projection of Ω^- . Below we shall find a quark transverse coordinates distribution function in a hyperon for the states with the 3/2 and 1/2 spin projections relative to the momentum direction. Considering $\Re(\mathbf{r}_1, \mathbf{r}_2)$ as an operator in hyperon spin space it is possible to expand it in terms of Cartesian spin-tensors of Ω^- - hyperon:

$$\Re(\mathbf{r}_1, \mathbf{r}_2) = \Re^0(\mathbf{r}_1, \mathbf{r}_2) + \frac{1}{2}\sum_{i,j}(S_iS_j + S_jS_i - \frac{5}{2}\delta_{ij})$$
$$\times(A(r_{1i}r_{1j} + r_{2j}r_{2i}) + Br_{1i}r_{2j})\,\widetilde{\Re}\,(\mathbf{r}_1, \mathbf{r}_2). \tag{12}$$

$\mathbf{S}$ is the hyperon spin operator. In (12) there are not terms of the first and third order of spin due to T-invariance, terms with higher spin powers are omitted by virtue of commutating relations. Considering the matrix element of $\Re(\mathbf{r}_1, \mathbf{r}_2)$ between the states with the spin projections m we get:

$$\Re_m(\mathbf{r}_1, \mathbf{r}_2) = \Re^0(\mathbf{r}_1, \mathbf{r}_2) + (-1)^{m+1/2}\Big(A(z_1^2 + z_2^2 - \frac{\eta_1^2 + \eta_2^2}{2})$$

$$+B(z_1 z_2 - \frac{\vec{\eta}_1\vec{\eta}_2}{2})\Big) \tilde{\Re}(\mathbf{r}_1, \mathbf{r}_2)). \quad (13)$$

To find the functions $\Re^0(\mathbf{r}_1, \mathbf{r}_2)$, $\tilde{\Re}(\mathbf{r}_1, \mathbf{r}_2)$ and the factors A, B it is necessary to choose some model of Ω^--hyperon, for example the nonrelativistic quark model (Gershtein, Zinoviev 1981). The wave function for the spin projection 3/2 has been calculated by Gershtein, Zinoviev 1981 and has the form:

$$| \, 3/2 >= 0.997 \, |^4 \, S > -0.068 \, |^4 \, D > -0.045 \, |^2 \, D > . \quad (14)$$

The expressions for $|^4 \, S >$, $|^4 \, D >$, $|^2 \, D >$ can be found in (Gershtein, Zinoviev 1981). To simplify our consideration we omit a small impurity of symmetrical radial excitation $|^4 \, S' >$ in (14). Multiplying the wave function of the $| \, 3/2 >$ state by the function conjugate to it the quark coordinates distribution function may be obtained:

$$\Re_{3/2}(\mathbf{r}_1, \mathbf{r}_2) = \frac{3\sqrt{3}}{R^6\pi^3} \exp\left(2\frac{-r_1^2 - r_2^2 - \mathbf{r_1 r_2}}{R^2}\right)\Big[1 + \frac{4 \times 0.068}{\sqrt{30}R^2}(\eta_1^2 + \eta_2^2 + \vec{\eta}_1\vec{\eta}_2 - 2(z_1^2 + z_2^2 + z_1 z_2)\Big] , \quad (15)$$

where $\mathbf{r}_i = (\vec{\eta}_i, z_i)$. Comparison of (15) with (13) gives $A = B = -8 \times 0.068/(\sqrt{30}R^2)$. R^2 is a mean squared radius of Ω^--hyperon. As a result of integrating equation (15) over z - coordinates, the quark distribution function over transverse coordinates turns out to be:

$$\wp_{\substack{3/2 \\ 1/2}}(\vec{\eta}_1, \vec{\eta}_2) = \frac{3}{R^4\pi^2} \exp\left(2\frac{-\eta_1^2 - \eta_2^2 - \vec{\eta}_1\vec{\eta}_2}{R^2}\right)\Big[1 \mp \frac{4 \times 0.068}{\sqrt{30}R^2}\Big(R^2 - \eta_1^2 - \eta_2^2 - \vec{\eta}_1\vec{\eta}_2\Big)\Big]. \quad (16)$$

At last we find a hyperon form factor required hereinafter:

$$G_{\substack{3/2 \\ 1/2}}(\mathbf{q}, \mathbf{q}') = \int \wp_{\substack{3/2 \\ 1/2}}(\vec{\eta}_1, \vec{\eta}_2) \exp(\mathbf{i}\mathbf{q}\vec{\eta}_1 + \mathbf{i}\mathbf{q}'\vec{\eta}_2)\mathrm{d}^2\vec{\eta}_1\mathrm{d}^2\vec{\eta}_2$$
$$= \exp\left(\frac{(-q^2 - q'^2 + \mathbf{q}\mathbf{q}')R^2}{6}\right)\left[1 \mp \frac{Q}{12}(q^2 + q'^2 - \mathbf{q}\mathbf{q}')\right], \quad (17)$$

where $Q = 8 \times 0.068 R^2/\sqrt{30}$ 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:

$$Q = \frac{2}{3}\int(\eta_1^2 + \eta_2^2 + \vec{\eta}_1\vec{\eta}_2 - 2(z_1^2 + z_2^2 + z_1 z_2))\Re_{3/2}(\mathbf{r}_1, \mathbf{r}_2)\mathrm{d}^3\mathbf{r}_1\mathrm{d}^3\mathbf{r}_2.$$

5. Expansion of the eikonal function on scattering multiplicities

The expression (7) for the scattering amplitude can be rewritten as:

$$F_m(\mathbf{q}) = \frac{\mathrm{i}}{2\pi}\int \mathrm{d}^2\mathbf{b}\mathrm{e}^{\mathrm{i}\mathbf{qb}}(1-\gamma_m(\mathbf{b})); \tag{18}$$

$$\begin{aligned}\gamma_m(\mathbf{b}) &=< m \mid \prod_{ij=1}^{3}(1-\Gamma(\mathbf{b}-\vec{\eta}_i+\vec{\eta}_j') \mid m > \\ &=< m \mid 1 - \sum_{ij}\Gamma_{ij} + \frac{1}{2!}\sum_{\substack{ij\\kl}}{}' \Gamma_{ij}\Gamma_{kl} - \frac{1}{3!}\sum_{\substack{ijk\\lpn}}{}' \Gamma_{ij}\Gamma_{kl}\Gamma_{pn} + ... \mid m > .\end{aligned} \tag{19}$$

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 (19):

$$\begin{aligned}\gamma_m(\mathbf{b}) \approx 1- &< m \mid \sum_{i,j}\Gamma_{ij} \mid m > + \frac{1}{2!} < m \mid \sum_{\substack{ij\\kl}}{}' \Gamma_{ij}\Gamma_{kl} \mid m > \\ &-\frac{1}{3!} < m \mid \sum_{\substack{ij\\kl}}{}' \Gamma_{ij}\Gamma_{kl} \mid m >< m \mid \sum_{pn}\Gamma_{pn} \mid m > \\ &+\frac{1}{4!} < m \mid \sum_{\substack{ij\\kl}}{}' \Gamma_{ij}\Gamma_{kl} \mid m >^2 - ... \\ &= ch\{\Omega_m'(\mathbf{b})\} - \Omega_m(\mathbf{b})\frac{sh\{\Omega_m'(\mathbf{b})\}}{\Omega_m'(\mathbf{b})},\end{aligned} \tag{20}$$

where

$$\Omega_m(\mathbf{b}) \equiv < m \mid \sum_{i,j}\Gamma_{ij} \mid m > = \frac{9}{2\pi \mathrm{i}}\int f(\mathbf{q})G_m(\mathbf{q})G'(\mathbf{q})\mathrm{e}^{-\mathrm{i}\mathbf{qb}}\mathrm{d}^2\mathbf{q} \ , \tag{21a}$$

$$\begin{aligned}(\Omega_m'(\mathbf{b}))^2 \equiv < m \mid \sum_{\substack{ij\\kl}}{}' \Gamma_{ij}\Gamma_{kl} \mid m > = -\frac{18}{4\pi^2}\int f(\mathbf{q})f(\mathbf{q}')[G'(\mathbf{q}+\mathbf{q}')G_m(\mathbf{q},\mathbf{q}') \\ +G'(\mathbf{q},\mathbf{q}')G_m(\mathbf{q}+\mathbf{q}') + 2G_m(\mathbf{q},\mathbf{q}')G'(\mathbf{q},\mathbf{q}')]\mathrm{e}^{-i(\mathbf{q}+\mathbf{q}')\mathbf{b}}\mathrm{d}^2\mathbf{q}\mathrm{d}^2\mathbf{q}'.\end{aligned} \tag{21b}$$

The form factor $G_m(\mathbf{q},\mathbf{q}')$ has been defined earlier (see (17))). $G'(\mathbf{q},\mathbf{q}')$ is a same quantity for a proton, $G'(\mathbf{q}) = G'(\mathbf{q},0)$, $G_m(\mathbf{q}) = G_m(\mathbf{q},0)$. The factorization (20) is minimal, in the sense that the each item in (19) is divided in the smallest number of multiplicands. Another factorization is offered by Franco,Varma 1978:

$$\gamma_m(\mathbf{b}) \approx \exp\left(-\Omega_m(\mathbf{b}) + \frac{1}{2}\left(\Omega_m'(\mathbf{b})\right)^2 - \frac{1}{2}\left(\Omega_m(\mathbf{b})\right)^2\right). \tag{22}$$

The total factorization of a series (19) corresponds to

$$\gamma_m(\mathbf{b}) \approx \exp\left(-\Omega_m(\mathbf{b})\right) \tag{23}$$

i.e. to the optical limit. The account only single and double collisions gives:

$$\gamma_m(\mathbf{b}) \approx 1 - \Omega_m(\mathbf{b}) + \frac{1}{2}\left(\Omega'_m(\mathbf{b})\right)^2 \ . \tag{24}$$

Let us show once more that the single collision contribution to the scattering amplitude at the zero angle does not depend on m: $F_m^{(1)}(0) = \frac{\mathrm{i}}{2\pi}\int \mathrm{d}^2\mathbf{b}\Omega_m(\mathbf{b}) = 9f(0)G_m(0)G'(0) = 9f(0)$. 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:

$$\begin{aligned} f(\mathbf{q}) &= f(0)\exp\left(-aq^2/2\right), \\ f(0) &= \frac{(\mathrm{i}+0.2)\sigma_{qs}}{4\pi}. \end{aligned} \tag{25}$$

$\sigma_{qs} = 3.2\ mb$ is the cross section of the s-quark - u,d-quark scattering, $a = 0.8\ Gev^{-2}$ (Furget *et al* 1990), for the 292.4 Gev hyperon energy in the proton rest frame ($\sqrt{s} = 23.5\ Gev$). Substituting the form factors (17) and amplitude (25) to the equations (21a),(21b) we obtain:

$$\begin{aligned} \Omega_{\substack{3/2\\1/2}}(\mathbf{b}) = -9\mathrm{i}f(0)\exp\left(\frac{-b^2}{2a+\frac{2}{3}R^2+\frac{2}{3}R'^2}\right)\left(a+\frac{1}{3}R^2+\frac{1}{3}R'^2\right)^{-1} \\ \times\left[1\pm\frac{Q}{12}\left(\frac{b^2}{(a+\frac{1}{3}R^2+\frac{1}{3}R'^2)^2}-\frac{2}{a+\frac{1}{3}R^2+\frac{1}{3}R'^2}\right)\right], \end{aligned} \tag{26a}$$

$$\begin{aligned} \Omega'^2_{\substack{3/2\\1/2}}(\mathbf{b}) = -18f^2(0)\Bigg\{&\exp\left(\frac{-b^2}{a+\frac{2}{3}R'^2+\frac{1}{6}R^2}\right)(a+\frac{1}{2}R^2)^{-1}(a+\frac{2}{3}R'^2+\frac{1}{6}R^2)^{-1} \\ &\times\left[1\pm\frac{Q}{12}\left(\frac{b^2}{(a+\frac{2}{3}R'^2+\frac{1}{6}R^2)^2}-\frac{4a+2R'^2+R^2}{(a+\frac{1}{2}R^2)(a+\frac{2}{3}R'^2+\frac{1}{6}R^2)}\right)\right] \\ &+\exp\left(\frac{-b^2}{a+\frac{2}{3}R^2+\frac{1}{6}R'^2}\right)(a+\frac{1}{2}R'^2)^{-1}(a+\frac{2}{3}R^2+\frac{1}{6}R'^2)^{-1} \\ &\times\left[1\pm\frac{Q}{3}\left(\frac{b^2}{(a+\frac{2}{3}R^2+\frac{1}{6}R'^2)^2}-\frac{1}{a+\frac{2}{3}R^2+\frac{1}{6}R'^2}\right)\right] \\ &+2\exp\left(\frac{-b^2}{a+\frac{R^2}{6}+\frac{R'^2}{6}}\right)(a+\frac{R^2}{2}+\frac{R'^2}{2})^{-1}(a+\frac{R^2}{6}+\frac{R'^2}{6})^{-1} \\ &\times\left[1\pm\frac{Q}{12}\left(\frac{b^2}{(a+\frac{R^2}{6}+\frac{R'^2}{6})^2}-\frac{4a+R^2+R'^2}{(a+\frac{R^2}{6}+\frac{R'^2}{6})(a+\frac{R^2}{2}+\frac{R'^2}{2})}\right)\right]\Bigg\}\ . \end{aligned} \tag{26b}$$

Optical limit of the (23) corresponds to the structureless hadrons whereas equations (20) and (22) imply constituent quark model .

6. 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 (Gribov 1969, Karmanov and Kondratyuk 1973) on a nucleon level, and in the problem of "color transparency" (Benhar *et al* 1996, Nikolaev 1993).

Formula (21*b*) 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 (21*b*) becomes:

$$(\Omega'_m(\mathbf{b}))^2 \equiv -\frac{18}{4\pi^2}\{\int (f(\mathbf{q})f(\mathbf{q}') + \sum_{n\neq 0} f_{0n}(\mathbf{q})f_{n0}(\mathbf{q}'))[G'(\mathbf{q}+\mathbf{q}')G_m(\mathbf{q},\mathbf{q}') +$$
$$+G'(\mathbf{q},\mathbf{q}')G_m(\mathbf{q}+\mathbf{q}')]\mathrm{e}^{-\mathrm{i}(\mathbf{q}+\mathbf{q}')\mathbf{b}}\mathrm{d}^2\mathbf{q}\mathrm{d}^2\mathbf{q}'$$
$$+2\int f(\mathbf{q})f(\mathbf{q}')G_m(\mathbf{q},\mathbf{q}')G'(\mathbf{q},\mathbf{q}')\mathrm{e}^{-\mathrm{i}(\mathbf{q}+\mathbf{q}')\mathbf{b}}\mathrm{d}^2\mathbf{q}\mathrm{d}^2\mathbf{q}'\}. \qquad (27)$$

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:

$$F_m^{(2)}(0) = \frac{\mathrm{i}}{2\pi}\int \mathrm{d}^2\mathbf{b}\frac{1}{2}\Omega'^2_m(\mathbf{b}) = \frac{-18\mathrm{i}}{4\pi}\Big[\int \sum_{n=0} f_{0n}(\mathbf{q})f_{n0}(-\mathbf{q})\Big(G'(0)G_m(\mathbf{q},-\mathbf{q})$$
$$+G'(\mathbf{q},-\mathbf{q})G_m(0)\Big)\mathrm{d}^2\mathbf{q} + 2\int f(\mathbf{q})f(\mathbf{q}')G'(\mathbf{q},-\mathbf{q})G_m(\mathbf{q},-\mathbf{q})\mathrm{d}^2\mathbf{q}\Big]$$
$$\approx \frac{-18\mathrm{i}}{4\pi}\Big[\sum_{n=0} f_{0n}(0)f_{n0}(0)\int\Big(G'(0)G_m(\mathbf{q},-\mathbf{q})$$
$$+G'(\mathbf{q},-\mathbf{q})G_m(0)\Big)\mathrm{d}^2\mathbf{q} + 2f(0)f(0)\int G'(\mathbf{q},-\mathbf{q})G_m(\mathbf{q},-\mathbf{q})\mathrm{d}^2\mathbf{q}\Big]. \qquad (28)$$

Under derivation of (28) 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 (Gribov 1973). 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 (Gribov 1973). If the quark excitation energy is about a pion mass m_π, then wave function of excited state of quark depends on time as $\sim \mathrm{e}^{\mathrm{i}m_\pi t}$. 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:

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

$$\Gamma(\hat{N},\hat{N}',\mathbf{b}) = -\sum_{k=1}^{\hat{N}*\hat{N}'} \frac{\hat{N}\hat{N}'(\hat{N}\hat{N}'-1)...(\hat{N}\hat{N}'-k+1)}{k!}\left(-\frac{3\mathrm{f}_p}{2\mathrm{i}r_q^2}\exp\left(-\frac{3b^2}{4r_q^2}\right)\right)^k$$
$$= 1-\left(1-\frac{3\mathrm{f}_p}{2\mathrm{i}r_q^2}\exp\left(-\frac{3b^2}{4r_q^2}\right)\right)^{\hat{N}\hat{N}'}, \tag{29}$$

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:

$$f(0) =< 0,0 \mid \hat{f}(0) \mid 0,0 >= \frac{\mathrm{i}}{2\pi}\sum_{N,N'} P(N)P(N')\int \Gamma(N,N',b)d^2b. \tag{30}$$

$\mid 0,0 >\equiv\mid 0 >\mid 0 >$, $\mid 0 >$ 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:

$$< 0,0 \mid \hat{f}(0) \mid 0 >< 0 \mid \hat{f}(0) \mid 0,0 >$$

$$= \frac{-1}{4\pi^2} \sum_{N,N',N''} P(N)P(N')P(N'') \int \mathrm{d}^2\mathbf{b}\mathrm{d}^2\mathbf{b}'\Gamma(N,N',b)\Gamma(N,N'',b'). \quad (31)$$

By reversing (30) it is possible to find f_p through $f(0)$ and substituting it in (31) 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 $(26b)$ instead of $f^2(0)$. Such a program was realized in our numerical calculations.

7. Results and discussion

We now substitute $\Omega'^2_{\substack{3/2\\1/2}}(\mathbf{b})$ and $\Omega_{\substack{3/2\\1/2}}(\mathbf{b})$ from equations $(26a)$, $(26b)$ in one of the equations (20), (22), (23), (24) for $\gamma_m(b)$ and through numerical integration of ereffmm 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 (Gershtein and Zinoviev 1981). The mean squared radiuses of a hyperon and proton we shall accept as 0.35 fermi squared (Gershtein and Zinoviev 1981) and 0.65 (Furget *et al* 1990) respectively. For the constants $f(0)$ and a we have from (25):

$$\begin{aligned} &f(0) = (5.6 \times 10^{-3}\ ,\ 2.8 \times 10^{-2}) \quad (fm)^2\ , \\ &a = 3.1 \times 10^{-2} \quad (fm)^2. \end{aligned} \quad (32)$$

In the table 1. it is shown the difference between the zero angle scattering amplitudes (real and imaginary parts). as well as dichroism and phase of spin oscillation of hyperon with the energy 292.4 Gev calculated with the various forms of function $\gamma_m(b)$. ϕ is the phase of oscillations of a hyperon spin:

$$\phi(z) = 2\pi\rho Re(F_{3/2}(0) - F_{1/2}(0))z, \quad (33)$$

and

$$A(z) = \frac{I_{1/2}(z) - I_{3/2}(z)}{I_{3/2}(z) + I_{1/2}(z)} = 2\pi\rho Im(F_{3/2}(0) - F_{1/2}(0))z \quad (34)$$

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. 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 (Collins and Squires 1968) and parton (Gribov 1973) theories the quantity a, proportional to the sum of mean squared radiuses of colliding quarks, grows as $ln(s)$, so, we can write roughly:

$$a(s^q) = a(s_0^q)\left(1 + ln\left(\frac{s^q}{s_0^q}\right)\right). \quad (35)$$

$\sqrt{s^q}$ 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 (25), it is possible to write from the Regge theory :

$$\sigma_{qs}(s^q) = \sigma_{qs}(s_0^q)\left(\frac{s^q}{s_0^q}\right)^{\Delta}. \tag{36}$$

We have taken the value $\Delta = 0.125$ from $p-p$ scattering data (Gotsman *et al* 1994). 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. 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 quarks with mean active parton number equal 1. If mean number of active partons grow 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. Let's return to spin dynamics of Ω^--hyperon. If the initial polarization vector of a hyperon lays on the plane x, z and is directed at an angle θ to the axes z, the hyperon initial spin wave function is determined as:

$$\hat{\psi}_0 = \{d^{3/2}_{3/2\;3/2}(\theta), d^{3/2}_{1/2\;3/2}(\theta), d^{3/2}_{-1/2\;3/2}(\theta), d^{3/2}_{-3/2\;3/2}(\theta)\},$$

where $d^S_{M\,M'}(\theta)$ is d-function of the finite rotation matrix. (Varshalovich *et al* 1975). Using equation (6) we obtain:

$$\begin{aligned}
< S_x > &= \frac{3}{4}\{\sin^3\theta\, \mathrm{e}^{-2n''_{1/2}kz} + \sin\theta(1+\cos\theta)\, \mathrm{e}^{-(n''_{3/2}+n''_{1/2})kz}\cos\phi\}/|\psi|^2, \\
< S_y > &= -\frac{3}{2}\sin\theta\cos\theta\, \mathrm{e}^{-(n''_{3/2}+n''_{1/2})kz}\sin\phi/|\psi|^2, \\
< S_z > &= \{\frac{3}{4}\cos\theta(1+\cos^2\theta)\, \mathrm{e}^{-2\,n''_{3/2}\,kz} + \frac{3}{8}\sin^2\theta\cos\theta\, \mathrm{e}^{-2\,n''_{1/2}\,kz}\}/|\psi|^2; \\
|\psi|^2 &= (1-\frac{3}{4}\sin^2\theta)\, \mathrm{e}^{-2\,n''_{3/2}\,kz} + \frac{3}{4}\sin^2\theta\, \mathrm{e}^{-2\,n''_{1/2}\,kz}.
\end{aligned} \tag{37}$$

From equations (37) we see that under the acute θ angle, initially zero quantity $< S_y >$ receives a negative increment, and under obtuse θ - a positive increment when ϕ increases. So in the first case the spin rotates counter-clockwise, and in second - clockwise if to look against hyperon motion. Initially zero quantity $< Q_{yz} >$ receives a negative increment in the first case and positive in second. Increment of initially zero magnitude $< Q_{xy} >$ is negative in the both cases. At $\theta = \pi/2$ $< S_y >$, $< S_z >$, $< Q_{xy} >$,

$< Q_{xz} >$ remains zero. Initially zero magnitude of $< Q_{yz} >$ receives an increment. The remaining quantities vary from nonzero initial values.

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 (33), (34). 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 (Diehl *et al* 1991) is applicable although higher statistics is needed.

8. 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.

Appendix

The 3/2 spins matrixes look like:

$$\hat{S}_x = \begin{pmatrix} 0 & \frac{\sqrt{3}}{2} & 0 & 0 \\ \frac{\sqrt{3}}{2} & 0 & 1 & 0 \\ 0 & 1 & 0 & \frac{\sqrt{3}}{2} \\ 0 & 0 & \frac{\sqrt{3}}{2} & 0 \end{pmatrix} \quad \hat{S}_y = \begin{pmatrix} 0 & \frac{-i}{2}\sqrt{3} & 0 & 0 \\ \frac{i}{2}\sqrt{3} & 0 & -i & 0 \\ 0 & i & 0 & \frac{-i}{2}\sqrt{3} \\ 0 & 0 & \frac{i}{2}\sqrt{3} & 0 \end{pmatrix}$$

$$\hat{S}_z = \begin{pmatrix} \frac{3}{2} & 0 & 0 & 0 \\ 0 & \frac{1}{2} & 0 & 0 \\ 0 & 0 & -\frac{1}{2} & 0 \\ 0 & 0 & 0 & -\frac{3}{2} \end{pmatrix}.$$

For the full description of spin properties of Ω^--hyperon as a particle of a spin 3/2 the knowledge of the mean values of quadrupole tensor

$$\hat{Q}_{ij} = \frac{1}{2}(\hat{S}_i\hat{S}_j + \hat{S}_j\hat{S}_i) - \frac{5}{4}\delta_{ij}$$

and octupole tensor

$$\hat{T}_{ijk} = \frac{5}{27}\left(Perm\{\hat{S}_i\hat{S}_j\hat{S}_k\} - \frac{41}{10}(\delta_{ij}\hat{S}_k + \delta_{jk}\hat{S}_i + \delta_{ki}\hat{S}_j)\right)$$

components are necessary. Here $Perm$ means all possible permutations of indexes. Averaging these operators over wave function (2), we obtain (without coping the values of polarization components already listed in (6)):

$$< \hat{Q}_{xy} >= -\sqrt{3}\{\mathrm{ac}\sin(\delta_{3/2} - \delta_{-1/2} + (n'_{3/2} - n'_{1/2})z)$$

$$+\mathrm{bd}\sin(\delta_{1/2} - \delta_{-3/2} - (n'_{3/2} - n'_{1/2})kz)\}\mathrm{e}^{-(n''_{3/2}+n''_{1/2})kz}/|\psi^2|,$$

$$< \hat{Q}_{xz} >= \sqrt{3}\{\mathrm{ab}\cos(\delta_{3/2} - \delta_{1/2} + (n'_{3/2} - n'_{1/2})kz)$$

$$-\mathrm{cd}\cos(\delta_{-1/2} - \delta_{-3/2} - (n'_{3/2} - n'_{1/2})kz)\}\mathrm{e}^{-(n''_{3/2}+n''_{1/2})kz}/|\psi^2|,$$

$$< \hat{Q}_{yz} >= \sqrt{3}\{-\mathrm{ab}\sin(\delta_{3/2} - \delta_{1/2} + (n'_{3/2} - n'_{1/2})kz)$$

$$+\mathrm{cd}\sin(\delta_{-1/2} - \delta_{-3/2} - (n'_{3/2} - n'_{1/2})kz)\mathrm{e}^{-(n''_{3/2}+n''_{1/2})kz}\}/|\psi^2|,$$

$$< \hat{Q}_{xx} >= \frac{1}{2}\{(-\mathrm{a}^2 - \mathrm{d}^2)\mathrm{e}^{-2n''_{3/2}kz} + (\mathrm{b}^2 + \mathrm{c}^2)\mathrm{e}^{-2n''_{1/2}kz}$$

$$+2\sqrt{3}[\mathrm{ac}\cos(\delta_{3/2} - \delta_{-1/2} + (n'_{3/2} - n'_{1/2})kz)$$

$$+\mathrm{bd}\cos(\delta_{1/2} - \delta_{-3/2} - (n'_{3/2} - n'_{1/2})kz)]\mathrm{e}^{-(n''_{3/2}+n''_{1/2})kz}\}/|\psi^2|,$$

$$< \hat{Q}_{yy} >= \frac{1}{2}\{(-\mathrm{a}^2 - \mathrm{d}^2)\mathrm{e}^{-2n''_{3/2}kz} + (\mathrm{b}^2 + \mathrm{c}^2)\mathrm{e}^{-2n''_{1/2}kz}$$

$$-2\sqrt{3}[\mathrm{ac}\cos(\delta_{3/2} - \delta_{-1/2} + (n'_{3/2} - n'_{1/2})kz)$$

$$+\mathrm{bd}\cos(\delta_{1/2} - \delta_{-3/2} - (n'_{3/2} - n'_{1/2})kz)]\mathrm{e}^{-(n''_{3/2}+n''_{1/2})kz}\}/|\psi^2|,$$

$$< \hat{Q}_{zz} >= \{(\mathrm{a}^2 + \mathrm{d}^2)\mathrm{e}^{-2n''_{3/2}kz} - (\mathrm{b}^2 + \mathrm{c}^2)\mathrm{e}^{-2n''_{1/2}kz}\}/|\psi^2|,$$

$$< \hat{T}_{xyz} >= \frac{5}{3\sqrt{3}}\{-\mathrm{ac}\sin(\delta_{3/2} - \delta_{-1/2} + (n'_{3/2} - n'_{1/2})kz)$$

$$+\mathrm{bd}\sin(\delta_{1/2} - \delta_{-3/2} - (n'_{3/2} - n'_{1/2})kz)\}\mathrm{e}^{-(n''_{3/2}+n''_{1/2})kz}/|\psi^2|,$$

$$< \hat{T}_{xxy} >= \{-\frac{1}{3}\mathrm{e}^{-2n''_{1/2}kz}\mathrm{bc}\sin(\delta_{1/2} - \delta_{-1/2}) - \frac{5}{3}\mathrm{e}^{-2n''_{3/2}kz}\mathrm{ad}\sin(\delta_{3/2} - \delta_{-3/2})$$

$$+\frac{1}{3\sqrt{3}}[\mathrm{ab}\sin(\delta_{3/2} - \delta_{1/2} + (n'_{3/2} - n'_{1/2})kz)$$

$$+\mathrm{cd}\sin\{\delta_{-1/2} - \delta_{-3/2} - (n'_{3/2} - n'_{1/2})kz)]\mathrm{e}^{-(n''_{3/2}+n''_{1/2})kz}\}/|\psi^2|,$$

$$< \hat{T}_{yyy} >= \{-\mathrm{e}^{-2n''_{1/2}kz}\mathrm{bc}\sin(\delta_{1/2}-\delta_{-1/2}) + \frac{5}{3}\mathrm{e}^{-2n''_{3/2}kz}\mathrm{ad}\sin(\delta_{3/2}-\delta_{-3/2})$$

$$+\frac{1}{\sqrt{3}}[\mathrm{ab}\sin(\delta_{3/2}-\delta_{1/2}+(n'_{3/2}-n'_{1/2})kz)$$

$$+\mathrm{cd}\sin(\delta_{-1/2}-\delta_{-3/2}-(n'_{3/2}-n'_{1/2})kz)]\mathrm{e}^{-(n''_{3/2}+n''_{1/2})kz}\}/|\psi^2|,$$

$$< \hat{T}_{zzy} >= \{\frac{4}{3}\mathrm{e}^{-2n''_{1/2}kz}\mathrm{bc}\sin(\delta_{1/2}-\delta_{-1/2})$$

$$-\frac{4}{3\sqrt{3}}[\mathrm{ab}\sin(\delta_{3/2}-\delta_{1/2}+(n'_{3/2}-n'_{1/2})kz)$$

$$+\mathrm{cd}\sin(\delta_{-1/2}-\delta_{-3/2}-(n'_{3/2}-n'_{1/2})kz)]\mathrm{e}^{-(n''_{3/2}+n''_{1/2})kz}\}/|\psi^2|,$$

$$< \hat{T}_{xxx} >= \{\mathrm{bce}^{-2n''_{1/2}kz}\cos(\delta_{1/2}-\delta_{-1/2}) + \frac{5}{3}\mathrm{ade}^{-2n''_{3/2}kz}\cos(\delta_{3/2}-\delta_{-3/2})$$

$$-\frac{1}{\sqrt{3}}[\mathrm{ab}\cos(\delta_{3/2}-\delta_{1/2}+(n'_{3/2}-n'_{1/2})kz)$$

$$+\mathrm{cd}\cos(\delta_{-1/2}-\delta_{-3/2}-(n'_{3/2}-n'_{1/2})kz)]e^{-(n''_{3/2}+n''_{1/2})kz}\}/|\psi^2|,$$

$$< \hat{T}_{zzz} >= \{\frac{1}{3}(\mathrm{a}^2-\mathrm{d}^2)\mathrm{e}^{-2n''_{3/2}kz} + (-\mathrm{b}^2+\mathrm{c}^2)\mathrm{e}^{-2n''_{1/2}kz}\}/|\psi|^2 \ ,$$

$$< \hat{T}_{zzx} >= \{-\frac{4}{3}\mathrm{bce}^{-2n''_{1/2}kz}\cos(\delta_{1/2}-\delta_{-1/2})$$

$$+\frac{4}{3\sqrt{3}}[\mathrm{ab}\cos(\delta_{3/2}-\delta_{1/2}+(n'_{3/2}-n'_{1/2})kz)$$

$$+\mathrm{cd}\cos(\delta_{-1/2}-\delta_{-3/2}-(n'_{3/2}-n'_{1/2})kz)]\mathrm{e}^{-(n''_{3/2}+n''_{1/2})kz}\}/|\psi|^2 \ ,$$

$$< \hat{T}_{xxz} >= \{\frac{1}{6}(-\mathrm{a}^2+\mathrm{d}^2)\mathrm{e}^{-2n''_{3/2}kz} + \frac{1}{2}(\mathrm{b}^2-\mathrm{c}^2)\mathrm{e}^{-2n''_{1/2}kz}$$

$$+\frac{5}{3\sqrt{3}}[\mathrm{ac}\cos(\delta_{3/2}-\delta_{-1/2}+(n'_{3/2}-n'_{1/2})kz)$$

$$-\mathrm{bd}\cos(\delta_{1/2}-\delta_{-3/2}-(n'_{3/2}-n'_{1/2})kz)]\mathrm{e}^{-(n''_{3/2}+n''_{1/2})kz}\}/|\psi|^2 \ ,$$

$$< \hat{T}_{yyz} >= \{\frac{1}{6}(-\mathrm{a}^2+\mathrm{d}^2)\mathrm{e}^{-2n''_{3/2}kz} + \frac{1}{2}(\mathrm{b}^2-\mathrm{c}^2)\mathrm{e}^{-2n''_{1/2}kz}$$

$$+\frac{5}{3\sqrt{3}}[-\mathrm{ac}\cos(\delta_{3/2}-\delta_{-1/2}+(n'_{3/2}-n'_{1/2})kz)$$

$$+\mathrm{bd}\cos(\delta_{1/2}-\delta_{-3/2}-(n'_{3/2}-n'_{1/2})kz)]\mathrm{e}^{-(n''_{3/2}+n''_{1/2})kz}\}/|\psi|^2 \ .$$

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Table 1. Amplitude difference (fm^2) with spin projections 3/2 and 1/2, oscillation phase (wich is approximately equal rotation angle) and dichroism for meter hydrogen target of 0.0675 g/cm^3 density. All quantities were calculated for the different form of $\gamma_m(b)$: column (a) corresponds to the equation (23), (b) - (22), (c) -(20), (d) -(24).

	a	b	c	d
$F_{3/2}(0) - F_{1/2}(0)$	2.0×10^{-4} 5.8×10^{-4}	2.8×10^{-4} 7.9×10^{-4}	3.0×10^{-4} 8.2×10^{-4}	4.3×10^{-4} 1.0×10^{-3}
ϕ	5.2×10^{-5}	7.1×10^{-5}	7.7×10^{-5}	1.1×10^{-4}
A	1.4×10^{-4}	2.0×10^{-4}	2.1×10^{-4}	2.6×10^{-4}

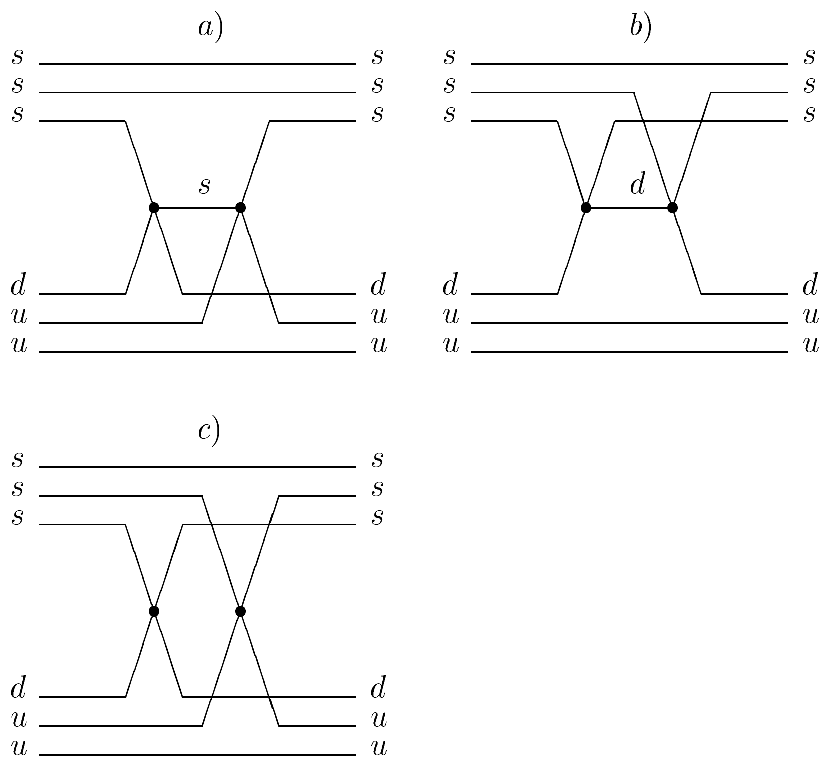

Figure 1. Diagrams of the double quark scattering contribution to the $\Omega^- - p$ elastic scattering.

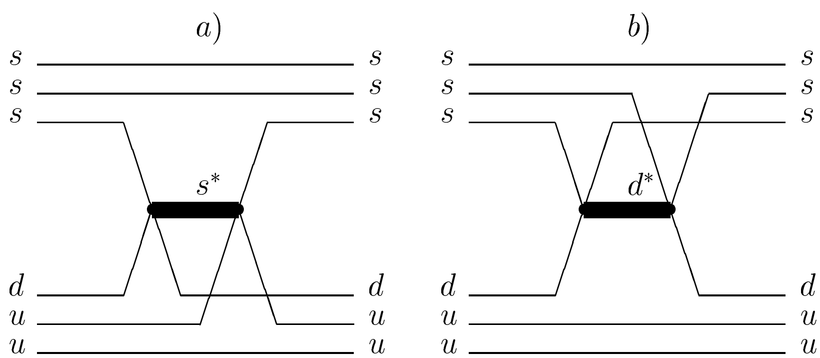

Figure 2. Diagrams of the inelastic corrections to the double quark scattering. * denotes excited quark state.

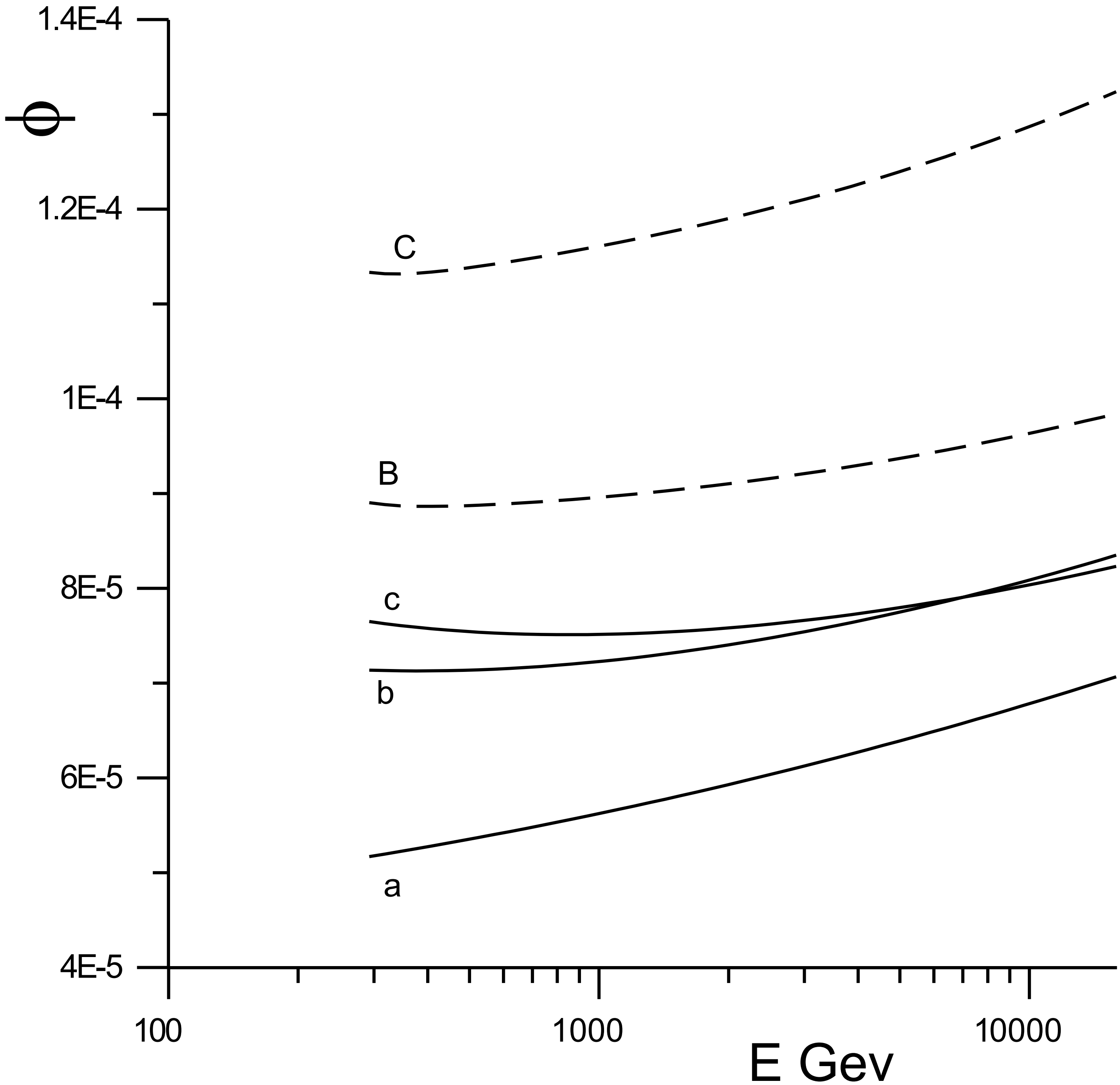

Figure 3. Energy dependence of Ω^{-}-hyperon spin oscillation phase (rotation angle) in hydrogen target, calculated for the different form of $\gamma_m(b)$: curve (a) corresponds to the equation (23), (b,B) - (22), (c,C) -(20).

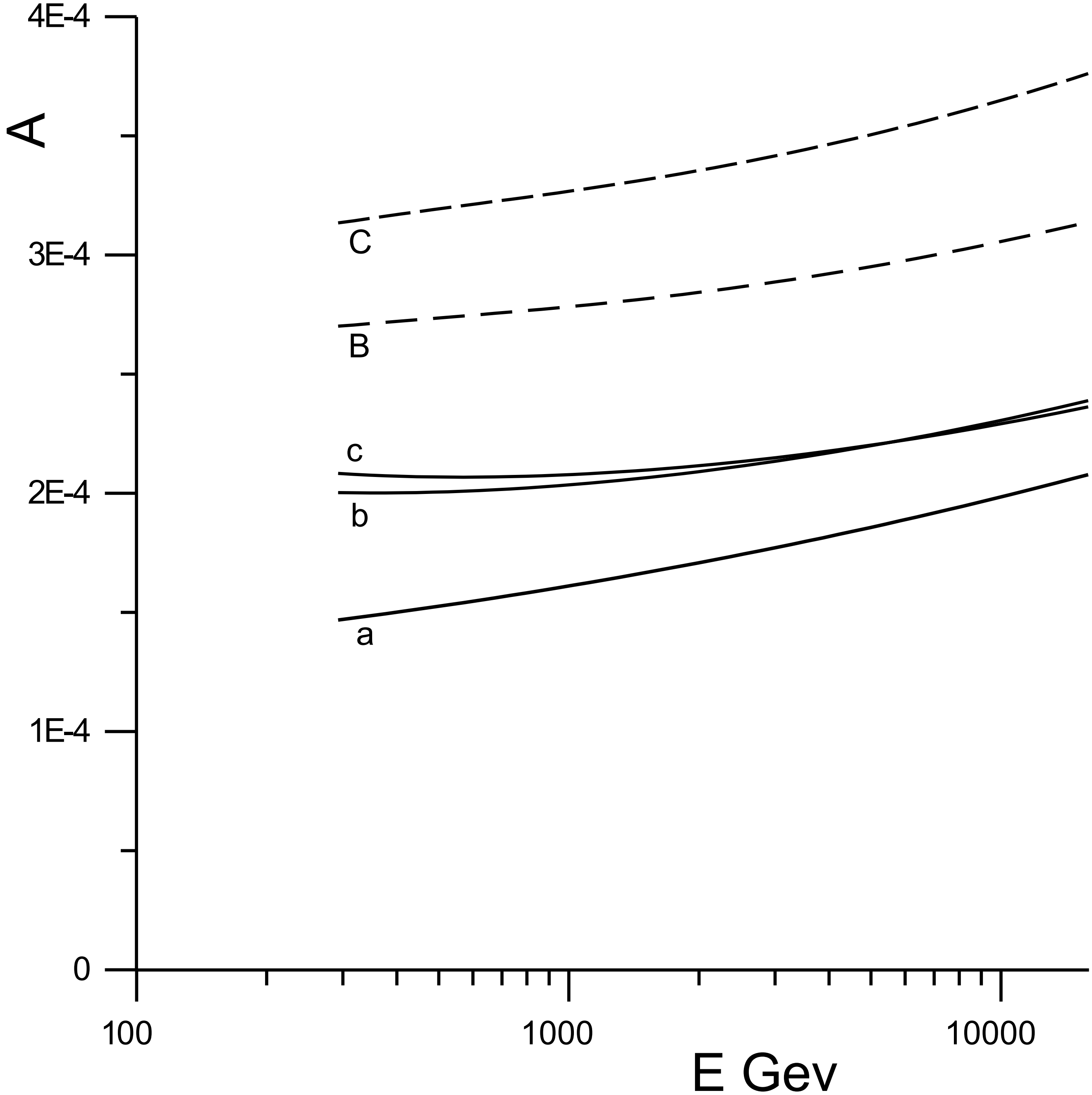

Figure 4. Energy dependence of Ω^--hyperon spin dichoism in hydrogen target, calculated for the different form of $\gamma_m(b)$: curve (a) corresponds to the equation (23), (b,B) - (22), (c,C) -(20).