Size of the hadron spin-flip amplitude
and energy dependence of CNI

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The energy dependence of the structure of the hadron spin-flip amplitude is examined. It is shown that the additional contribution due to the hadron spin flip amplitude to the clear CNI effect has the heavily s and t dependence.

There is a proposal to use the Coulomb-nucleon interference (CNI) effects to measure very exactly and faster the beam polarization [1]. After the first paper [2] a number of papers appeared which consider these questions and try to estimate a possible contribution of the hadron spin-flip amplitude to the CNI effect. Our difficulty is in most part defined by the lack of experimental data at high energies and small transfer momenta. We should examine the available experimental data at different energies and in different domains of momentum transfers. In most analyses this energy difference is not considered. Of course, we have plenty of experimental data in the domain of small momentum transfers at low energies $3 < p_L < 12\ GeV/c$. But at these energies we have many contributions to the hadron spin-flip amplitudes coming from different regions exchange. Now we cannot exactly calculate all contributions and find their energy dependencies. But great amount of the experimental material allows us to make full phenomenological analyses and obtain the size and form of the different parts of the hadron scattering amplitude at one low energy. In this talk we show that we have to introduce different dependencies on s and t in the spin-nonflip parts and spin-flip parts of the hadron scattering amplitude as we want examine the available experimental data [3].

Let us take the electromagnetic helicity amplitudes in the usual one-photon approximations with the Coulomb-hadron phase [4] calculated for the whole diffraction range. The total helicity amplitudes can be written as $\Phi_i(s,t) = \phi^i_N(s,t) + \phi^i_C(t)exp(i\phi)$. With the usual high energy approximation for the spiral amplitudes at very small momentum transfers we suppose that $\phi_1 = \phi_3$ and we can neglect the contributions of ϕ_2 and ϕ_4. As asymptotic amplitudes let us take those calculated in Ref. [5]. It is essential that the model predicts large polarization effects for all considered reactions at high and superhigh energies. The predictions are in good agreement with the experimental data in the energy region available for experiment. As a low energy amplitude let us take the one obtained in Ref. [6] where the full analysis of experimental data has been carried out and the full set of the helicity spin amplitudes and their eikonals of the proton-proton scattering at $p_L = 6\ GeV/c$ has been extracted. To obtain the smooth transform to our model representation, let us multiply the low energies amplitudes by the function $fs^{nf,fl}$ quickly decreasing with energy, multiply our model amplitudes by the factor $1 - fs^{nf,fl}$: In this case, we obtain that the analyzing power at $p_L = 6\ GeV/c$ is described only by the amplitudes obtained in Ref. [6] and at superhigh energies only by the DM amplitude.

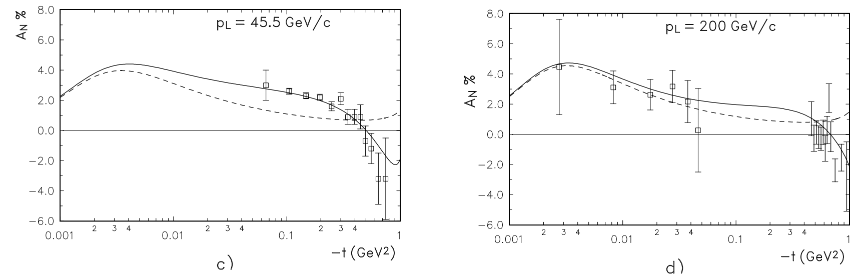

Fig.1: The A_N of pp-scattering calculated at a) at $p_L = 45.5\ GeV/c$; b) at $p_L = 200\ GeV/c$ (the full line is our calculations, dashed line is the calculation without the hadron spin-flip amplitude.)

The experimental data at $p_L = 11.75\ GeV/c$ seriously differ from those at $p_L = 6\ GeV/c$ but our calculations reproduce them sufficiently well. Our calculations at $p_L = 45.5\ GeV/c$ show also the satisfactory description of the experimental data (see Fig. 1a). At this energy both of our parts of the amplitude gives important contributions. The contributions to the analyzing power of the low energy amplitudes are approximately twice as large as the contributions of the model amplitudes. From Fig. 1a we can see that in the region $|t| \approx 0.2\ GeV^2$ the contributions from the hadron spin-flip amplitudes are most important. Fig. 1b shows our calculations at $p_L = 200\ GeV/c$. At this energy, the contributions of the phenomenological amplitudes are already very small and can be compared with the contributions of the model amplitudes only at $|t| = 0.5\ GeV^2$ where both the contributions are very small. The chosen energy dependence of the hadron spin-dependent amplitude allows us to describe all available experimental material. It is very important to note that we obtain the different energy dependencies of the additional contributions ΔA_N to the pure CNI effect at the different points of momentum transfers. The contribution at $|t| = 0.1\ GeV^2$ has a clear downfall with growing $\sqrt{s}$ but in the range of maximum of the CNI effect we have the additional contributions which are nearly independent of energy. So, we cannot make the conclusion about energy dependence of ΔA_N at the place of maximum of CNI, measuring the energy dependence of the analyzing power at other points of the transfer momentum. But this is one of the central points of many other analyses of the CNI effect.

If we examine the ratio of the real and imaginary parts of the spin-flip amplitude, without the kinematic factor $\sqrt{|t|}$, to the separate parts of the hadron spin-nonflip amplitude we find that this ratio can be regarded as a constant only up to $|t| \leq 0.1\ GeV^2$. Moreover, this ratio has a very strong energy dependence.

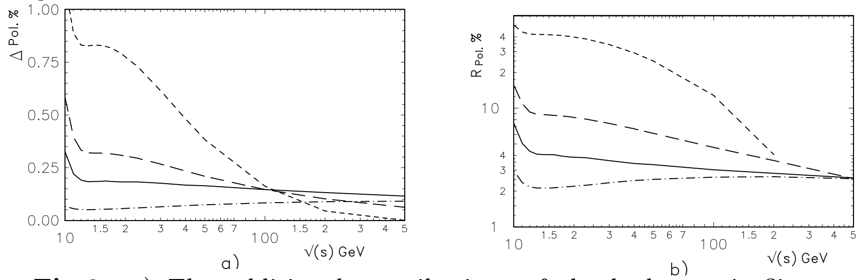

Fig.3: a) The additional contributions of the hadron spin-flip amplitudes to the CNI effect; b) the relative contributions of the hadron spin-flip amplitudes to the CNI effect (our calculations at t_{max}, $|t| = 0.001\ GeV^2$, $|t| = 0.01\ GeV^2$, $|t| = 0.1\ GeV^2$ are shown by the full, dot-dashed, long-dashed and dashed lines respectively)

Hence, we cannot carry out our analysis of experimental data at different energies and different regions of momentum transfers using the same form of the hadron spin-flip amplitude. Note that we obtain that the imaginary part of the hadron spin-flip amplitude, without the kinematic factor $\sqrt{|t|}$, is smaller than the imaginary part of the spin-nonflip amplitude. But this kind of ratio for the real parts is not so far from unity. Our descriptions of all available experimental data give about 3.5% the predictions for RHIC energies for the contributions of the hadron spin-flip amplitude to the maximum of the CNI effect. But, of course, this estimation has a very large theoretical indefiniteness which is connected with other possible contributions from other sources of the hadron spin-flip at high energies.

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