An application of the U-matrix approach to high energy processes

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Abstract

The U-matrix method of the unitarized amplitude construction is considered in both polarized and nonpolarized cases. The method is applied to investigate two problems: low Bjorken variable x behavior of nuclear structure function $F_{2A}(x, Q^2)$ and high energy behavior of pp-scattering helicity amplitudes.

General principles of quantum mechanics require the unitarity of the S-matrix. The unitarity imposes a bound on the high energy behavior of amplitudes, cross sections, structure functions, etc.

The U-matrix approach [1] allows to obtain the analytical continuation of model amplitude from annihilation to direct channel which satisfies the unitarity. From the physical point of view the unitarization procedure corresponds to rescattering on various nucleons or quarks depending on a type of process.

Present data seem to violate the unitarity (power-like behavior of cross sections or structure functions). It happens because at present energies rescattering does not come into play. But at certain energies rescattering starts playing important role and changes the behavior.

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In general there are two ways to take rescattering into account: the multiple scattering theory by Glauber and Sitenko and the U-matrix theory. The U-matrix approach gives formulas which are more convinient for analytical calculations. Briefly, the U-matrix method is as follows: one should construct U-matrix and then solve algebraic equations [1] to find physical amplitude in the impact parameter representation.

The U-matrix method works fine in both polarized and nonpolarazed cases. Here are two examples of an application of the U-matrix.

In order to obtain low x behavior of $F_{2A}(x, Q^2)$ we unitarize the amplitude of $q\bar{q}$-pair scattering on nucleon using U-matrix approach [2]. Gaussian, sharp-edge and Woods-Saxon nuclear density distributions have been considered. For the gluon distribution as a function of x phenomenological (power-like) expression have been taken. For Gaussian and Woods-Saxon distributions the behavior is logarithmic: $\ln 1/x$. For sharp-edge distribution the behavior is constant. Also such well-known nuclear effect as shadowing could be easily seen from final expressions for $F_{2A}(x, Q^2)$.

The question of the importance of spin effects at high energies is still opened. So we investigate pp-scattering helicity amplitudes at high energies [3]. In this domain pomeron exchange gives main contribution into amplitude. We use the model of pomeron from [4]. In this model pomeron-proton vertex doesn't conserve helicity. Non-conserving term contains isoscalar anomalous magnetic moment of nucleon μ. The U-matrix method is used to obtain expressions for 5 independent helicity amplitudes. The relative contribution of single helicity-flip amplitudes is determined by the ratio r_5 which in our model equals to $\mu/2 \approx 5\%$.

References

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