

Referee's report on the doctoral thesis by Ing. Mark Matas:

Phenomenological studies of QCD at high energies

The presented dissertation is focused on verifying the validity and applicability of the color dipole model in combination with the evolution equation Balitsky-Kovchegov (BK). This is a continuation and deeper elaboration of his diploma thesis from 2016. The main goal of this work is to investigate the gluon distribution functions generated for various conditions using the indicated model approach. Gluons and their presence in strong interaction systems are based on a theoretical description that follows from quantum chromodynamics (QCD). However, calculations based on the first principles of QCD are practically possible only for a very limited class of processes. In many other situations, only model approaches with QCD motifs can be used for the calculation. Such models, if they agree with the experimental data, can significantly contribute to a deeper understanding of the mechanism of strong interactions within QCD. The chosen model approach in the dissertation also falls into this category. Therefore, the topic of the presented work is undoubtedly very actual.

The work is clearly divided into several parts. The general introduction defining the issue is followed by a theoretical overview (chapter 2), which summarizes and explains the basic concepts of the phenomenology of DIS (deep inelastic scattering) and its representation in the color dipole model. The next part (chapter 3) is devoted to the explanation of the evolution equation BK and its application to the color dipole model. Its definition and methods of solution in various conditions and approaches with input QCD parameters are explained. The legitimacy of the method is demonstrated by calculations for specific scenarios for which experimental data are available. For instance, the calculated structure functions $F_2(x, Q^2)$ coincide very well with the corresponding experimentally measured functions. Very good agreement is also achieved for the calculation of the dependences of the differential effective cross section of the J/ψ photoproduction. The strength of the model is in its ability to predict some dependencies also for nuclear targets.

Further part of the work (chapter 4) is devoted to the analysis of saturation effects. Saturation of gluon distribution functions at small x is an expected effect of QCD and is directly related to the presence of 3-gluon vertices, which are characteristic for QCD. However, it is an effect in the nonperturbative region, so its direct calculation is problematic. Therefore, it is necessary to look for side effects of saturation at least in the data and with the help of models. The author focused on the study of the production of two jets within a model approximation based on the formalism of TMDs (transverse momentum distribution functions). In a given approximation, these functions are generated by the color dipole model.

In chapter 5, the obtained results are briefly and clearly summarized. An important part of the work is also chap. 6, which contains copies of published works with the results obtained for the dissertation. There are three articles in Phys.Rev.D, three recent articles (so far) in the form of preprints (arXiv) and four papers in conference proceedings. Overall, I believe that the author has convincingly done a solid piece of very demanding work. His dissertation contains very valuable, actual results. I have no critical remarks on the content of the work, but during the defense I would welcome a brief comment on the following issues:

1. The co-authors of the articles in chapter 6 are probably arranged alphabetically. It is obvious that the results were obtained within the cooperation of a smaller team of authors. It would therefore be appropriate for the author of the dissertation to specify his contribution to the common articles.

2. What is the relationship between TMD in Figure 4.4 and TMDs in chap. 4.6? What is the normalization of these distributions? For which x is Fig. 4.4 obtained? How does the Q_s parameter depend on x ?

A few minor typos can certainly be tolerated. In summary, however, I can conclude that the author undoubtedly applied a number of interesting ideas in the processing of very current issues. The new scientific knowledge was obtained, the methods used are adequate. The form of processing corresponds to the accepted standards. The work fulfilled its goal, in which the author proved the preconditions for independent creative work.

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Mgr. Petr Závada CSc., DSc.