REVIEW OF THE DISSERTATION SUBMITTED BY DAGMAR BENDOVÁ

Thesis title: Low-x QCD studies using the Balitsky-Kovchegov equation

The dissertation focuses on theoretical and phenomenological studies of the non-linear QCD dynamics that is expected to manifest itself in hadrons at very high collision energies. A particular focus is to develop a method to describe the energy (or Bjorken-x) dependence of the proton structure by using the Balitsky-Kovchegov (BK) evolution equation to which dependence on the proton or nuclear geometry is included. This evolution is used to compute predictions for different cross sections sensitive to proton and nuclear high-energy structure, and an excellent description of the available high-energy deep inelastic scattering data is obtained.

State-of-the-art methods, in particular the BK equation with dependence on the hadron geometry, are further developed and applied in phenomenology in this work. Given the developments in recent years that have made it possible to measure photon-induced processes in Ultra Peripheral Collisions at the LHC, and the fact that the world's first electron-nucleus collider, the Electron-Ion Collider, will be constructed during the next ten years, the topic of this thesis addresses some of the most important and urgent questions in the field using state-of-the-art methodology.

The thesis consists of an introduction to the non-linear QCD physics and summarizes results the candidate has obtained and that are reported already in five peer-reviewed publications published in main international journals in the field. Additionally, some currently unpublished interesting results related to NLO BK evolution equation with impact parameter dependence are discussed. The most important scientific value of each paper briefly commented below, which demonstrate that the goals of the research have been achieved.

- Paper 1 ("*Dissociative production of vector mesons at electron-ion colliders*"): using the previously developed so-called hot-spot model the candidate discovers that this approach results in dissociative vector meson production cross section to have a unique signature (cross section reaching a maximum value at the given predicted center-of-mass energy) that can be seen to be a signal of non-linear QDC dynamics.
- Paper 2 ("*Solution to the Balitsky-Kovchegov equation with the collinearly improved kernel including impact-parameter dependence*"): The candidate proposes a solution to one of the important problems in the field: how to include effective confinement scale effects in the perturbative evolution equation maintaining predictive power. In this paper it is demonstrated numerically that when

higher order corrections enhanced by large transverse logarithms are resumed, non-perturbative contributions originating from long distance scale effects are strongly suppressed.

- Paper 3 (*"Diffractive deeply inelastic scattering in future electron-ion colliders"*): Using the impact parameter dependent BK equation developed in Paper 2, predictions for diffractive structure functions measured at HERA are calculated and a good description of the available data is obtained, which highlights the possibility to simultaneously describe multiple different high-energy datasets from the developed formalism which is a stringent test for the gluon saturation picture employed in this research. Additionally important predictions for future nuclear deep inelastic scattering measurements are presented and their impact is estimated.
- Paper 4 (*"Photonuclear J/ψ production at the LHC: Proton-based versus nuclear dipole scattering amplitudes"*): the candidate calculates exclusive J/ψ meson production in photon-induced processes and shows that one particular description for the interaction between the quark-antiquark pair and a heavy nucleus is preferred by the LHC data, and that the nuclear effects predicted from the applied saturation physics framework are compatible with the LHC data.
- Paper 5 (*"Deeply virtual Compton scattering at the EIC and LHeC: a comparison among saturation approaches"*): The applied framework is used to calculate predictions for exclusive photon production (deeply virtual Compton scattering) in electron-proton collisions measured at HERA and at future nuclear-DIS experiments, complementing the above discussed J/ψ production as the exclusive photon production does not require a non-perturbative modeling of the final state vector meson wave function.

The thesis itself is well written. I only have a few relatively minor questions/comments to the candidate:

- Chapter 1.1.1: The candidate writes that "DIS processes could, in theory, be also mediated by the electroweak bosons". In the context of this Thesis such contributions are indeed negligible, but for example there is a lot of charged current (W exchange) data from HERA.
- Chapter 1.2.2: below (1.23) it says that "the virtual photon can be seen as a qq fluctuation with the quantum numbers of vacuum". I don't understand how a qq pair can have vacuum quantum numbers. Maybe the author refers to a "pomeron exchange" between the qq dipole and the target?
- Chapter 2.1: The factorized impact parameter dependence shown in Eq. (2.1.) is indeed in practice useful but comes with a caveat that now the maximum scattering amplitude is less than 1 at center impact parameter. Does the candidate think that this is an important effect in practice?
- Chapter 2.1: In the applied model the number of hot spots increase with

increasing energy, but I would expect that the slope of the coherent vector meson production spectra (and as such the size of the proton) remains approximatively constant in this model and does not describe the proton growth towards small-x as seen in HERA data. How would the W dependence of the results presented in this thesis change if the proton size would also increase compatible with the HERA data?

- Chapter 2.2: Is it applicable to use the applied model to calculate rho meson production in the very low Q^2 region shown in Figs. 2.2 and 2.3.
- Chapter 2.3: What does it mean that the energy W_{GSS} at which the maximum of the dissociative cross section takes place can fluctuate?
- Chapter 4.3.2: what are the effects "beyond simple electromagnetic interaction" that can potentially explain the apparent issue to describe the shape of the t spectrum in Fig. 4.17 at very small $|t|$?
- Chapter 5.3: The candidate analyses the NLO BK evolution by modifying the kernel of the evolution kernel by dropping the *K_sub* contribution. The obtained results are shown in Table 5.5 for example. However, the role of the *K_sub* term is to subtract the explicit NLO contribution from the resummation of single transverse logarithms included in the term *K_STL*. Consequently it seems that there is now double counting in these results without the *K_sub* term, as the same NLO contribution is now included both in the LO-like kernel *K_STL* and in the explicit NLO contribution to the BK equation. Is my interpretation of the results here correct, and if so, how does it affect the interpretation of results presented in Chapter 5.3?

Overall, I find the thesis and the phenomenological and numerical analyses presented to be of high quality. I recommend it for presentation and defense.

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