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Report

on

the PhD Dissertation entitled with "Initial configurations and fusion of color strings as origin of collective signatures in p+p interactions at high energies", Specialization 1.3.3. Theoretical physics, prepared by Prokhorova Daria Sergeevna and submitted for the degree of Candidate of Physical and Mathematical Sciences at Saint Petersburg State University.

Based on the ideas that the color string formation and fragmentation approach are to be connected with the description of strong interaction, this dissertation aims to model the multi-particle production and other collective phenomena observed in inelastic p+p interactions. The candidate decided to specifically utilize interacting color strings which are finite at rapidity and put forward taking after following objectives: i) to find the influence of the longitudinal dynamics of strings with finite rapidity on the multiplicity correlations in separated rapidity regions, ii) to analytically relate the strongly intensive quantity $\Sigma[N_F, N_B]$, factorial cumulants and asymmetry coefficient of N_F-N_B, iii) to estimate the impacts of the transverse dynamics of strings and their fusion on the correlation function $\langle p_T \rangle$-N, iv) to define the possible collectivity signatures specially for the behavior of strongly intensive variables in the model, v) to confront these signatures to the experimental data available, and vi) to assess the interplay of the proposed mechanisms of azimuthal anisotropy of particles in the model, namely particle boosts by overlapped fused strings and particle's momentum quenching in the inhomogeneous string environment. For instance, the last objective is novel. For the first time, the attraction potential between color strings and their fusion are simultaneously considered for particle boosts and quenching of their momentum in the string medium. Also, the depiction of the interaction of some number of colour strings formed in p+p event as a multistage process taking into account their transverse and longitudinal dynamics, as well as their fusion into clusters. Last but not least, the results obtained confirm that the theoretical assumptions of the color string seem to induce the appearance of the non-trivial long-range contributions to the correlation and fluctuation measures as well as particular azimuthal anisotropies consistent with the experimental observations.

The background in string theory, especially, that with the imposed assumptions, is well formulated. The three chapters of the thesis are well designed and comprehensively structured. Their contents pedagogically introduce the proposed model and allow to draw concrete conclusions:

- The first chapter introduces a toy model for interacting strings which are finite in rapidity. It aims to implement the N_F-N_B correlation coefficients, as well as the strongly intensive quantity and the correlations of N_F-N_B.
- The second chapter is devoted to the transverse evolution of string density due to string attraction. After a description of p+p interactions as multi-pomeron exchange, the formation

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of sting, and the parton composition of protons, the candidate explored partial chiral symmetry restoration and the transverse and longitudinal evolution of string density and then integrated sting fusion. Before constructing the model, the candidate described the process of effective string hadronization. The model formalism is then outlined and followed by calculations for inelastic p+p interactions at 900GeV. This chapter also formulates a connection of $\Sigma[N_F, N_B]$ with the asymmetry coefficient.

- The third chapter introduces a further enhancement. The model that starts as a "toy model" and gained a remarkable enhancement to incorporate the transverse evolution of string density due to string attraction, now gets its second improvement which is not less that an advanced mechanisms of "string-string" and "string-particle" interactions. This allows to address the challenging question of the origin of the collective azimuthal particles' flows observed in inelastic proton-proton interactions.

The thesis overall is clear and without shortcomings. This thesis comes with original contributions to the multi-particle production and other collective phenomena observed in inelastic p+p interactions. Its pedagogical concepts, innovative motivations, and detailed derivations make the thesis as a good reference for researchers and especially for students who shall be engaged in this domain in future.

I believe that this work satisfies the requirements for partial fulfillment of the Ph.D. degree completion of Prokhorova Daria Sergeevna. The thesis and published peer reviewed journals present clear evidence of novel contributions to scientific knowledge and foster our understanding for the area of study. Therefore, I am in favor of the attribution to Prokhorova Daria Sergeevna of the Degree of Candidate of Candidate of Physical and Mathematical Sciences, Specialization 1.3.3. Theoretical physics!

Yours Sincerely,

Abdel Nasser Tawfik, D.Sc., Dr.rer.Nat, PhD.
Cairo, June 10, 2024