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Report about the thesis:

"Semihard Parton Rescatterings in Heavy Ion Interactions at Collider"

by ALBERTO ACCARDI

A. Accardi has submitted a thesis dealing with the perturbative QCD dynamics of partons in nucleus-nucleus collisions. This work is coming at the right time, since the new accelerator RHIC has just started its operations and experiments for LHC are in their planning stages.

His thesis starts with a general overview of nucleus-nucleus collisions. He puts his work based on parton-parton interactions into the context of the search for the quark gluon plasma. From the Glauber model the basic geometric features of multiple scattering are developed and the separation in soft and hard processes is prepared. This chapter gives a good insight into the basics of the field and shows that the candidate has close contact to the rapidly developing phenomenology of nucleus-nucleus collisions.

Chapter 2 contains one of the major pieces of work in A. Accardi's thesis. Based on D. Treleani's ideas of multiparton distributions in nuclei he develops a closed analytic expression for the minijet cross section. This expression contains the unitarization of the cross section and allows rescattering of the partons during the interaction. In its most general form it also includes correlation terms in the multi-parton distribution. A central role in this framework is played by the separation scale between soft and hard collisions. Parton-parton collisions with momentum transfers $p > p_0$ are considered hard collisions where the parameter p_0 is varied between 0.7 GeV < 3 GeV. A. Accardi uses this formalism to calculate average quantities like the number of wounded partons, the number of collisions and average transverse energy generated in the collision.

In chapter 3, the relevance of the parton-parton cascade for the later stages of the heavy-ion collisions is discussed. In this chapter the nuclear parton distributions are approximated as uncorrelated. The number of minijets is rather insensitive to the cut-off p_0, if additional rescatterings occur (cf. fig. 3.1). An important question is discussed here for the first time: Do production $2 \to 3$ processes, i.e. does gluon radiation $qq \to qqg$ essentially change the results. The author states that the effective parton-parton energy for LHC collision is rather small $\sqrt{s_{pp}} \approx 25$ GeV, such that 3-jet events are not so numerous. It must be said, however, that radiation is indispensable to get equilibration and to understand p_T-spectra.

Chapter 5 follows up the rescattering approach with explicit calculations of transverse momentum distributions of minijets. Here the simplification of hadron-nucleus collisions is made. Numerical results for a screened gluon exchange cross section are obtained which demonstrate nicely the two effects of rescatterings. At small $p_\perp$ the minijet cross section is decreased, whereas at intermediate $p_\perp$ the cross section receives additional contributions (cf. fig. 5.1 right). This enhancement can explain the Cronin effect which is observed in (hadron-$A \to h'(p_T) + X$) cross sections. A detailed comparison with experiment is not made, but would have been interesting to assess the approximations made in the calculation. Besides, energy loss (or gluon radiation) and absorption of the produced hadrons modify the p_T-transverse spectra of hadrons.

The thesis is supplemented by a discussion of saturation effects in heavy ion collisions. This subject is very fashionable, the theoretical tools are still in development and rather crude. The number of gluons $xG(x, Q^2)$ saturate at a scale Q_s^2 which in nuclei depends on the thickness function of the nucleus $T(b)$. Using this saturation scale one can estimate the number of produced gluons and relate these to the observed charged particle multiplicity as done in chapter 4. The contribution of A. Accardi to this problem has been to emphasize the role of the area, where saturation of the produced gluons occurs. On the other hand he has been able to make a connection from his work on minijet production to the work on saturation. With the assumption that 70% - 80% of the upper bound of the minijet multiplicity means saturation, he can derive a cut-off p_0, which leads to meaningful charged particle multiplicities (cf. fig. 4.11). This phenomenological work and comparison to RHIC experiments support the underlying hypothesis of this thesis, that the semihard processes give a majority of the interaction processes in the initial stages of heavy-ion collisions (fraction $F_{s \cdot h} \approx 0.8$). The result, however, corresponds to a rather small scale $p_0 \simeq 0.7$ GeV for a perturbative approach. A. Accardi gives interesting predictions for the central multiplicities at LHC.

In conclusion I would like to express my strong appreciation of the analytical and numerical work presented in this thesis. I find that A. Accardi has convincingly derived his main results. He has been able to successfully make contact with the newest RHIC experiments. His overview of the field gives a good impression about his conceptual qualities. I strongly support the acceptance of this thesis as qualification for the Ph.D. in physics.

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