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Predictions for R_{AA} in 5.36 TeV C + C, O + O, and Ne + Ne collisions at the LHC

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Experiments on collisions of light nuclei at $\sqrt{s} = 5.36$ TeV have recently begun at the LHC. In this regard we make predictions for nuclear modification factor R_{AA} in 5.36 TeV C + C, O + O, and Ne + Ne collisions for scenarios with and without quark-gluon plasma formation in *pp* collisions. We find a sizeable difference in R_{AA} for these two scenarios, which grows with decreasing atomic number. This says that data on R_{AA} for light nuclei could potentially give information on the presence of jet quenching in *pp* collisions.

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The formation of a quark-gluon plasma (QGP) has been observed in heavy ion collisions in experiments at RHIC and LHC. One of the key signatures of the QGP formation in AA collisions is suppression of high-p_T hadron spectra (jet quenching) due to parton radiative and collisional energy loss in the QGP (for reviews, see [1, 2]). There are some indications that at the LHC energies a QGP can be formed in pp/pA collisions as well [3].

The medium suppression of high-p_T hadrons in AA collisions is quantified by the nuclear modification factor R_{AA}, defined as the ratio

$$R_{AA} = \frac{d^2N(AA \to hX)/dp_T^2dy}{N_{ev}\langle T_{AA}\rangle_{\Delta c} d^2\sigma(pp \to hX)/dp_T^2dy}, \quad (1)$$

where $N(AA \to hX)$ is the hadron yield, N_{ev} is the number of events, $\langle T_{AA}\rangle_{\Delta c}$ is the nuclear overlap function for centrality bin Δc. In calculations of the R_{AA} in the scenario without mini-QGP formation in *pp* collisions one can use for the reference $pp \to hX$ cross section in the denominator of (1) ordinary pQCD cross section $d^2\sigma_{pQCD}(pp \to hX)/dp_T^2dy$. In the scenario with mini-QGP formation in *pp* collisions, the real inclusive *pp* cross section differs from the pQCD one by the medium modification factor R_{pp}, i.e.,

$$\frac{d^2\sigma(pp \to hX)}{dp_T^2dy} = R_{pp}\frac{d^2\sigma_{pQCD}(pp \to hX)}{dp_T^2dy}. \quad (2)$$

The R_{pp} is an unobservable quantity. But it modifies the theoretical R_{AA}, since in this scenario the real R_{AA} reads [4, 5]

$$R_{AA} = \frac{R_{AA}^{st}}{R_{pp}}, \quad (3)$$

where R_{AA}^{st} is defined via the pQCD *pp* cross section. The results of a global analysis of the data from RHIC and LHC on R_{AA} in heavy ion collisions [6] (based on the light-cone path integral approach to induced gluon emission [7]) show that data on R_{AA} in heavy ion collisions can be described equally well in the scenarios with and without mini-QGP formation in *pp* collisions. But for 7 TeV O + O collisions it was found that R_{AA} in the scenario with mini-QGP formation in *pp* collisions turns out to be noticeably larger than that in the scenario without mini-QGP formation in *pp* collisions.

Recently experiments on light ion collisions have begun at the LHC for $\sqrt{s} = 5.36$ TeV [8]. This makes it interesting to perform calculations of R_{AA} in light ion collisions at this energy. In the present work we perform calculations of R_{AA} in 5.36 TeV C + C, O + O, and Ne + Ne collisions that can be measured in the LHC experiments. We perform calculations of R_{AA} for light nuclei within the LCPI jet quenching scheme of [6] for scenarios with and without mini-QGP formation in *pp* collisions. We describe the QGP fireball evolution within Bjorken's 1+1D model [9]. We calculate the QGP density in AA and *pp* collisions through Bjorken's relation [9] between the entropy and charged multiplicity density. For AA collisions the latter has been calculated within the Glauber wounded nucleon model. The induced gluon spectrum and the collisional energy loss

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are calculated with running α_s parametrized in the form (supported by the lattice results [10])

$$\alpha_s(Q,T) = \begin{cases} \dfrac{4\pi}{9\log(\frac{Q^2}{\Lambda^2_{QCD}})} & \text{if } Q > Q_{fr}(T) \ , \\ \alpha_s^{fr}(T) & \text{if } Q_{fr}(T) \geq Q \geq cQ_{fr}(T) \ , \\ \frac{Q\alpha_s^{fr}(T)}{cQ_{fr}(T)} & \text{if } Q < cQ_{fr}(T) \ , \end{cases} \tag{4}$$

with $Q_{fr} = \kappa T$, $c = 0.8$, $Q_{fr}(T) = \Lambda_{QCD} \times \times \exp\left\{2\pi/9\alpha_s^{fr}(T)\right\}$ (we take $\Lambda_{QCD} = 200\,\mathrm{MeV}$). We fitted κ to the LHC data on R_{AA} in 5.02 TeV Pb + Pb collisions.

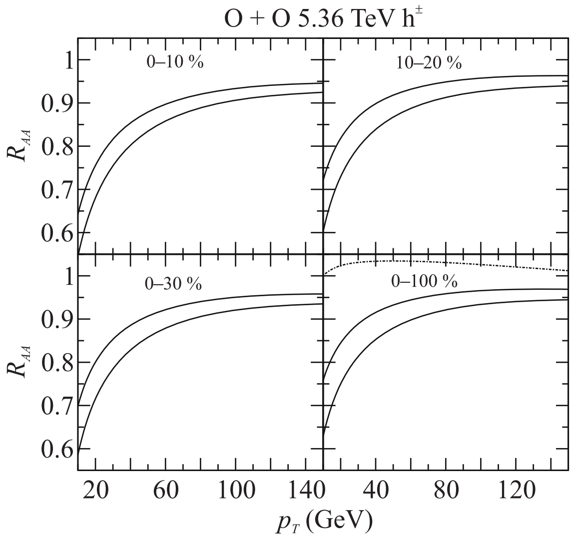

Fig. 1. R_{AA} of charged hadrons in 5.36 TeV O + O collisions for the scenarios with and without (top to bottom) QGP formation in *pp* collisions. Long dash-dotted line shows R_{AA}^{pdf}

In Figure 1 we present the numerical results for R_{AA} in 5.36 TeV O + O for 0–10 %, 10–20 %, 0–30 %, and 0–100 % centrality classes for the optimal values of the parameter $\kappa = 2.35$ and 3.2 in scenarios with and without QGP formation in *pp* collisions fitted to data on R_{AA} in 5.02 TeV Pb + Pb collisions . Also, we show in Fig. 1 the factor R_{AA}^{pdf} calculated without the parton energy loss in the QGP with the LO EPS09 [11] corrections to the nucleon PDFs. Preliminary data from the CMS Collaboration [12] on O + O collisions support the scenario with QGP formation in *pp* collisions.

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