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New vistas in ultraperipheral and peripheral heavy ion collisions

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We present calculation of cross sections for diphoton production
in (semi)exclusive $PbPb$ collisions, relevant for the LHC.
The calculation is based on equivalent photon approximation in
the impact parameter space.
The cross sections for elementary $\gamma\gamma \to \gamma\gamma$
subprocess are calculated including two different mechanisms.
We take into account box diagrams
with leptons and quarks in the loops.
In addition, we consider a vector-meson dominance (VDM-Regge) contribution
with virtual intermediate hadronic (vector-like) excitations of the photons.
We get much higher cross sections in $PbPb$ collisions
than in earlier calculation from the literature.
This opens a possibility to study the $\gamma\gamma \to \gamma\gamma$
(quasi)elastic scattering at the LHC.
We present many interesting differential distributions which could
be measured by the ALICE, CMS or ATLAS Collaborations at the LHC.
We study whether a separation or identification of different components
(boxes, VDM-Regge) is possible. We find that the cross section for elastic
$\gamma\gamma$ scattering could be measured in the heavy-ion collisions
for subprocess energies smaller than $W_{\gamma\gamma} \approx 15 - 20$ GeV. A first confrontation of our results with very recent
ATLAS data will be given for ligh-by-light scattering.

We discuss also the two-gluon exchange contribution (formally three-loops)
to elastic photon-photon scattering in the high-energy approximation.
The elastic $\gamma\gamma \to \gamma\gamma$ amplitude is given in
the impact-factor representation for all helicity configurations
and finite quark masses.
We discuss the importance of including the charm quark,
which contribution, due to interference, can enhance the cross section
considerably.
We investigate the contribution to the $\gamma\gamma \to \gamma\gamma$
amplitude from the soft region, by studying its dependence
on nonperturbative gluon mass.
Helicity-flip contributions are shown to be much smaller than
helicity-conserving ones. We identify region(s) of phase space where
the two-gluon exchange contribution becomes
important ingredient compared to box and nonperturbative
VDM-Regge mechanisms considered in the literature.
Consequences for the $AA \to AA\gamma\gamma$ reaction are
discussed. Several differential distributions are shown.
A feasibility study to observe the effect of two-gluon exchange is presented.
We perform a similar analysis for the $pp \to pp\gamma\gamma$
reaction. Only by imposing severe cuts on $M_{\gamma\gamma}$ and
a narrow window on photon transverse momenta the two gluon contribution
becomes comparable to the box contribution but the corresponding cross
section is rather small.

We present first measurable predictions for electromagnetic (two-photon)
double scattering production of two positron-electron pairs
in ultraperipheral heavy-ion collisions at RHIC and LHC.
Measureable cross sections are obtained with realistic cuts
on electron/positron (pseudo)rapidities and transverse momenta
for the ALICE and ATLAS or CMS experiments.
The predictions for total and differential cross sections

are presented. We show also two-dimensional distributions
in rapidities of the opposite-sign (from the same or different subcollisions)
and of the same-sign (e^+e^+ or e^-e^-) electrons
and in rapidity distance between them.
Expected number of events are presented and discussed.
Our calculations strongly suggest that relevant measurements
with the help of ATLAS, CMS and ALICE detectors
are possible in a near future.

Finally we present results of calculation for total
and differential cross sections for J/ψ photoproduction
in ultrarelativistic both ultraperipheral and for the first time for
peripheral (semi-central)
lead-lead collisions at the LHC energy $\sqrt{s_{NN}} = 2.76$ TeV.
In the present approach we use a simple model based on vector dominance
picture and multiple scattering of the hadronic ($c\bar{c}$) state
in a cold nucleus as an example.
In our analysis we use both the classical mechanics and quantum (Glauber)
formulae for calculating $\sigma_{tot}(J/\psi Pb)$ which is a building
block of our model.
We compare our UPC results with ALICE and CMS data.
For semi-central collisions ($b < R_A + R_B$)
a modification of the photon flux seems necessary.
We discuss different physics motivated approximations.
We try to estimate the cross sections for different centrality bins
and for J/ψ mesons emitted in forward rapidity range ($2.5 < y < 4$)
corresponding to recent ALICE experimental results.
Reasonable results are obtained but open questions are discussed.

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