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Modeling multiplicity distributions in relativistic heavy-ion collisions at NICA energies

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This work presents a comprehensive analysis of charged-particle multiplicity distributions in relativistic heavy-ion collisions, focusing on systems and energies relevant to the first stages of NICA collider experimental program (Bi+Bi, Xe+Xe, and Xe+W). Utilizing three theoretical frameworks—the Glauber two-component model [1], the Color Glass Condensate (CGC) [2], and the EKRT saturation model [3]—we investigate the dependence of multiplicity density on collision centrality, energy, and geometry.
The Glauber model Monte Carlo (GMC) approach [4] provides geometric parameters such as the number of participants (Npart) and binary collisions (Ncoll) for centrality classification. Input parameters, including nuclear density profiles and inelastic nucleon-nucleon cross-sections, are calibrated using RHIC and LHC data. Centrality-dependent tables for Npart and Ncoll are generated for Bi+Bi, Xe+Xe and Xe+W systems, enabling comparisons with experimental data. Results highlight a consistent rise in multiplicity by participant pair with Npart for two-component Glauber and CGC models, while the EKRT model predicts a suppression due to gluon saturation effects [1,4].
Notably, none of the models reproduce the "upstick" effect observed in LHC Xe+Xe data [5], underscoring the need for future NICA-MPD measurements. These findings emphasize the role of initial-state geometry and energy dependence in constraining QCD matter properties at extreme baryon densities.
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