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Influence of the residual magnetic field on the azimuthal distribution of final-state particles in photonuclear processes

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In relativistic heavy-ion collisions, charged particles are accelerated to nearly the speed of light, and their external electromagnetic fields can be effectively approximated as quasi-real photons. These photons interact with another nucleus via photon-nuclear interactions, producing vector mesons. These vector mesons possess extremely low transverse momentum ($p_T \sim 0.1$ GeV/c), distinguishing them from particles produced via hadronic interactions. STAR and ALICE have observed J/ψ, ρ^0 and other vector mesons with very low p_T, which are well described by photoproduction models. This unique characteristic of having extremely low transverse momentum allows them to serve as a novel experimental probe. Recent STAR results show that the equivalent photons in photoproduction processes are fully linearly polarized, affecting the azimuthal distribution of final-state particles like $\rho^0 \to \pi^+\pi^-$. Since the polarization links to the initial collision geometry, the ρ^0 azimuthal modulation can probe nuclear structure. However, the post-collision magnetic field may deflect these particles, distorting the azimuthal distribution and complicating structure measurements. We simulated the distribution of residual magnetic fields over time under different collision conditions using UrQMD for Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV and calculated their effects on the azimuthal modulation ($\langle cos2\phi \rangle$) of photoproduced ρ^0. Our results show that in peripheral collisions, the field significantly alters the $\langle cos2\phi \rangle$ for photoproduced ρ^0 with $p_T \approx 0.1$ GeV/c. This provides key insights for future nuclear structure studies via photoproduction in peripheral collisions.

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