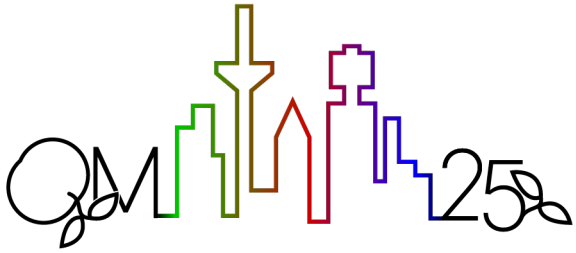

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Exploring the impact of strong-force fields on ϕ-meson spin alignment within a quantum relativistic transport approach

The unexpected pattern of global spin alignment of vector mesons observed in relativistic heavy-ion collisions for different particle species have posed a strong challenge to theoretical interpretation, as it cannot be explained solely through conventional polarization sources such as vorticity and electromagnetic fields. We argue that fluctuations of strong-force fields with short correlation length may be the key to solve the puzzle. We derive a relativistic spin Boltzmann equation for vector mesons from Kadanoff-Baym equations, incorporating an effective quark-meson model for interaction and the quark coalescence process for hadronization. Our calculations of the spin density matrix element ρ_{00} for unflavored vector mesons reveal that all field contributions appear in squared terms. This finding indicates that anisotropies in local field correlations, relative to the spin quantization axis, lead to the spin alignment of unflavored vector mesons. We propose that the large spin alignment observed for ϕ mesons at lower energies arises from effective ϕ fields that polarize the strange quarks and antiquarks, which in turn form polarized ϕ mesons via coalescence during the hadronization stage. The strength of the ϕ field can be inferred from the experimental data on ϕ-meson spin alignment as functions of collision energy reported by STAR Collaboration. Our findings show a transverse momentum dependence of ρ_{00} in fair agreement with STAR data, and we also predict the azimuthal angle dependence of ρ_{00}. The proposed polarization mechanism driven by fluctuating strong-force fields may open a new window into a hitherto unknown behaviour of QCD interaction.
[X.-L. Sheng, L. Oliva, Z.-T. Liang, Q. Wang and X.-N. Wang, Phys. Rev. Lett. 131, 042304 (2023)]
[X.-L. Sheng, L. Oliva, Z.-T. Liang, Q. Wang and X.-N. Wang, Phys. Rev. D 109, 036004 (2024)]

Category

Theory

Collaboration (if applicable)

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