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Differential measurements of ϕ -meson global spin alignment and off-diagonal spin density matrix elements in Au+Au collisions at STAR

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A significant global spin alignment (ρ_{00}) signal for ϕ -mesons was observed by the STAR collaboration in Au+Au collisions using the data from the first phase of the Beam Energy Scan at RHIC (BES-I) [1]. Conventional physical mechanisms which contribute to ρ_{00} fail to explain the observed signal; however, it may be attributable to the presence of a ϕ -meson strong force field [2] or to non-zero ρ_{00} in the helicity frame induced by the relative motion of $s\bar{s}$ pairs to the thermal background in heavy-ion collisions [3]. Recently, a quark recombination model with quark-antiquark spin correlations was developed and is able to simultaneously explain lambda polarization (P_Λ) and ϕ -meson ρ_{00} measurements, in addition to predicting non-zero off-diagonal spin density matrix elements [4]. Therefore, measurements of off-diagonal matrix elements of ϕ -mesons may provide a probe of $s\bar{s}$ spin correlations. Off-diagonal spin density matrix elements could also be important when measuring Chiral Magnetic Effect (CME) observables involving vector meson decay products, as these elements represent a possible physics background [5]. Previous ρ_{00} measurements in [1] use a 1D angular distribution in θ^* (polar angle of a daughter kaon in the ϕ -meson's rest frame with respect to the orthogonal of the harmonic plane), which cannot account for possible contributions to ρ_{00} from off-diagonal spin density matrix elements. In this talk, we address this by measuring ϕ -meson ρ_{00} and off-diagonal spin density matrix elements using both angular dimensions θ^* and β of a daughter kaon in the ϕ -meson's rest frame, where β is the azimuthal angle within the reaction plane, measured relative to the beam axis. We will present differential measurements of ϕ -meson global ρ_{00} and off-diagonal spin density matrix elements with respect to rapidity and transverse momentum, using data from the second phase of RHIC BES (BES-II) in Au+Au collisions at $\sqrt{s_{NN}} = 19.6$ GeV collected by STAR.

- [1] STAR Collaboration., *Nature* **614**, 244–248 (2023)
- [2] X.L. Sheng et al., *Physical Review C* **108**, 054902 (2023).
- [3] X.L. Sheng et al., *Physical Review D* \textbf{110}, 056047 (2024).
- [4] J.P. Lv et al., *Physical Review D* \textbf{109}, 114003 (2024).
- [5] Z. Wang et al., *Physical Review C* \textbf{111}, 014910 (2025)

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