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Advances in Measuring Global Spin Density Matrix Elements of Vector Mesons in Heavy-Ion Collisions

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The STAR Collaboration reported a significant ϕ-meson global spin alignment (ρ_{00}) signal in Au+Au collisions at $\sqrt{s_{NN}} \leq 62$ GeV by measuring the one dimensional (1D) polar angle distribution of ϕ-meson daughters with respect to the orbital angular momentum direction of the collision system [1].
This talk summarizes methodological developments from a recent paper on a two-dimensional (2D) method that considers the polar and azimuthal angle distributions, enabling simultaneous extraction of ρ_{00} and off-diagonal spin density matrix elements (SDMEs) for vector mesons in heavy-ion collisions [2].
This new method provides unique access to local quark-antiquark spin correlations and spin hydrodynamics in quark-gluon plasma, in addition to removing potential biases from non-zero off-diagonal SDMEs on ρ_{00} extracted with the 1D method [3-6].
Models invoking a strong meson force field or non-zero helicity frame ρ_{00} induced by the relative motion of $s\bar{s}$ pairs to the thermal background in heavy-ion collisions have been able to describe the 1D ρ_{00} results from [1]; however, these models assume off-diagonal SDMEs are zero [7-12]. A recently developed quark recombination model with quark-antiquark spin correlations is able to simultaneously explain ϕ-meson ρ_{00} measurements and lambda polarization (P_Λ) [3]. A distinctive feature of this model is the prediction of possible non-zero off-diagonal SDMEs. In this talk, a detailed procedure to correct for detector acceptance and resolution effects will be presented and validated using simulation studies, advancing experimental efforts towards measuring vector meson SDMEs and understanding their physical origin.

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