First measurement of Ω and Ξ directed flow and electric-charge-dependent violation of quark coalescence in Au+Au collisions from BES-II data

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We report the first measurement of the rapidity-odd directed flow (v_1) of Ω and Ξ baryons in Au+Au collisions as recorded by the STAR detector in BES-II at RHIC. We focus on hadron species, namely $K^-(\bar{u}s)$, $\bar{p}(\bar{u}\bar{u}\bar{d})$, $\bar{\Lambda}(\bar{u}\bar{d}\bar{s})$, $\phi(s\bar{s})$, $\overline{\Xi}^+(\bar{d}\bar{s}\bar{s})$, $\Omega^-(sss)$, and $\overline{\Omega}^+(\bar{s}\bar{s}\bar{s})$, whose constituent quarks are produced in the medium instead of transported from initial state. We demonstrate using a new method [1] that the coalescence sum rule holds for hadron combinations with identical quark content. We further examine the sum rule with similar quark masses but different electric charge (Δq) and strangeness (ΔS), e.g. $\Delta v_1 = v_1(\Omega^-) - v_1(\bar{\Omega}^+)$, which is sensitive to the violation of the sum rule. The measurement uses BES-II Au+Au collisions at $\sqrt{s_{NN}}$ = 14.6, 19.6, and 27 GeV, and also collisions at $\sqrt{s_{NN}}$ = 200 GeV. We measure v_1 as a function of rapidity, and thus obtain the Δq and ΔS dependence of the Δv_1 slope ($d\Delta v_1/dy$) between different combinations of particles. The $d\Delta v_1/dy$ increases with Δq and ΔS, and the signal becomes stronger at lower collision energies. We compare the results with calculations from the Parton-Hadron String Dynamics (PHSD) model with electromagnetic (EM) field which suggests that the violation of the sum rule is caused by the strong EM field which couples to the v_1 of produced quarks and anti-quarks in opposite directions. In addition to the EM field, the sum rule is also violated due to the presence of transported quarks, such as in $p(uud)$. Hence, we also present a data driven decomposition of the v_1 of p into two components, an initial component and a medium generated component, related to the transported quarks and the produced quarks in the medium, respectively. This decomposition provides a new way to probe separately the equation of state and dynamics of the medium in BES energies.

References

[1] A. I. Sheikh, D. Keane and P. Tribedy, arXiv:2110.04283 [nucl-ex].