Probing strong magnetic-field and baryonic Spin Hall effect via spin polarization of Λ and $\overline{\Lambda}$ in Au+Au collisions from the RHIC Beam Energy Scan

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A significant global spin polarization of Λ hyperons in the first phase of RHIC Beam Energy Scan (BES) provides evidence of vorticity of the QGP created in heavy-ion collisions. The data also hint at a larger polarization of $\overline{\Lambda}$ than that of Λ, which is expected from a strong late-stage magnetic field sustained by the medium. A decisive experimental test of this splitting would be highly significant, as it could reveal valuable information about the electric conductivity of the QGP [1]. Similarly, the local polarization of Λ and $\overline{\Lambda}$ hyperons are predicted to be different due to the polarization induced by the gradient of baryonic chemical potential (analogous to the electric field) and called baryonic spin Hall effect. This effect is expected to be observable through the energy dependence of the angular modulation of the net polarization [2], $P^{net}_{x,y,z} = P^{\Lambda}_{x,y,z} - P^{\overline{\Lambda}}_{x,y,z}$, as measured by $P^{net}_{x,z}\sin(2\phi_{\Lambda} - 2\Psi_2)$ and $P^{net}_{y}\cos(2\phi_{\Lambda} - 2\Psi_2)$, where Ψ_2 is the second-order event-plane.

We report the first measurement of splitting in global and local spin polarization between Λ and $\overline{\Lambda}$ hyperons in heavy-ion collisions using data collected by the STAR experiment during the second phase of the RHIC Beam Energy Scan (BES II) with the upgraded STAR detectors. We present results of Λ global polarization as a function of centrality, transverse momentum, and rapidity in Au+Au collisions at $\sqrt{s_{NN}} = 19.6$ and 27 GeV. We also present local polarization measurements in Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7—27 GeV. Our measurements provide important insights into the late-stage magnetic field sustained by the QGP, as well as spin Hall currents possibly created in a highly dense baryonic environment.

[1] L. McLerran, V. Skokov, Nucl. Phys. A 922, 184 (2014).
[2] B. Fu et al, arXiv: 2201.12970 (2022).