Significant charge splitting of rapidity-odd directed flow slope and its implication on electromagnetic effect in Au+Au, $^{96}_{44}$Ru+$^{96}_{44}$Ru, and $^{96}_{40}$Zr+$^{96}_{40}$Zr collisions from STAR

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ABSTRACT

Heavy-ion collisions can produce an ultra-strong magnetic field, the evolution of which was predicted to decrease (increase) the directed flow slope, dv_1/dy, for positively (negatively) charged particles [1, 2]. In this work, we study this effect with large statistics datasets accumulated for Au+Au, $^{96}_{44}$Ru+$^{96}_{44}$Ru, and $^{96}_{40}$Zr+$^{96}_{40}$Zr isobar collisions at $\sqrt{s_{NN}}$ = 200 GeV, and Au+Au collisions at $\sqrt{s_{NN}}$ = 27 GeV. The charge dependent dv_1/dy splitting, $\Delta(dv_1/dy)$, will be presented for $\pi^{\pm}$, $K^{\pm}$, and (anti)proton. A finite $\Delta(dv_1/dy)$ between protons and anti-protons has been observed and it changes from positive to negative as a function of centrality from central to peripheral collisions. This is the first observation of a significant negative $\Delta(dv_1/dy)$ between proton and anti-protons. A similar decreasing trend of slope difference between K^+ and K^- has also been observed in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV and 27 GeV, and in isobar collisions with less significance. The slope difference between π^+ and π^- is negative and decreases as a function of centrality in Au+Au collisions at $\sqrt{s_{NN}}$ = 27 GeV, while no significant slope difference is observed in Au+Au and isobar collisions at $\sqrt{s_{NN}}$ = 200 GeV. Our measurements of significant negative $\Delta(dv_1/dy)$ cannot be explained by conventional mechanisms (e.g. transported quarks), but qualitatively agree with the theoretical prediction with an ultra-strong electromagnetic field in peripheral collisions.

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[1] U. Gursoy, D. Kharzeev, E. Marcus *et al.* Phy.Rev.C, **98** 055201 (2018).
[2] U. Gursoy, D. Kharzeev and K. Rajagopal. Phy.Rev.C, **89** 054905 (2014).