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Non-interdependent Collective Motions in Heavy-ion Collisions

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The widely used Fourier expansion for studying collective motions in heavy-ion collisions implies that different modes of collectivity could be non-interdependent, driven by factorized actions in the created nuclear medium. Following this line of thought, we assume each non-dependent collective motion modulates the probability of particle emission with a single-harmonic Fourier expansion, and then express the final-state particle azimuthal distribution as the product of these expansions,
$\frac{2\pi}{N^{\pm}}\frac{dN^{\pm}}{d\varphi} = \prod_{n=1}^{\infty}(1+2\tilde{a}_n^{\pm}\sin n\Delta\varphi)\prod_{n=1}^{\infty}(1+2\tilde{v}_n^{\pm}\cos n\Delta\varphi)$, instead of a long linear Fourier series. Here, $\Delta\varphi$ is the particle azimuthal angle with respect to the reaction plane. This scheme may better capture the genuine strength of each collectivity mode ($\tilde{a_n}$ and $\tilde{v_n}$), and results in non-leading cross terms between collectivity modes, with significant impacts on experimental observables. We explore the possibility that the chiral magnetic effect (CME) [1] and elliptic flow can evolve separately, thereby their convolution affecting not only the observable that is sensitive to the CME, but also that to the shear-induced CME [2]. We employ the event-by-event anomalous-viscous fluid dynamics model to showcase the implications of this scenario on searches for the CME. In addition, we also propose practical experimental tests using conventional flow harmonics and exploit a multiphase transport model to demonstrate the emergence of non-leading cross terms, such as the rapidity-odd component of triangular flow. The universality of the assumption regarding factorized actions can be investigated by analyzing real data collected from RHIC and the LHC, which will enhance our understanding of the collective motions.

[1] D. E. Kharzeev, L. D. McLerran and H. J. Warringa, Nucl. Phys. A 803, 227 (2008).

[2] M. Buzzegoli, D. E. Kharzeev, Y.-C. Liu, S. Shi, S. A. Voloshin, H.-U. Yee, Phys. Rev. C 10, L051902 (2022).

Category

Theory

Collaboration (if applicable)

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