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New paradigm in anisotropic flow analyses with correlation techniques

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The measurements of anisotropic flow in heavy-ion collisions were crucial in establishing the perfect-liquid paradigm about quark–gluon plasma (QGP) properties. Most of these results were obtained with two- and multi-particle correlation techniques, which are in an environment characterized by large multiplicities and large flow values a precision tool. However, in the flow measurements in small-collision systems, correlation techniques are not reliable.

To make further progress, we reconcile for the first time the strict mathematical formalism of multivariate cumulants with the usage of cumulants in anisotropic flow analyses. We demonstrate that properties of cumulants are preserved only for the stochastic observables on which the cumulant expansion has been performed directly, and if there are no underlying symmetries due to which some terms in the cumulant expansion are identically zero. This reconciliation yields to the next generation of observables to be used in flow analyses which do satisfy all fundamental properties of cumulants: symmetric and asymmetric cumulants of flow amplitudes, cumulants of symmetry plane correlations, and event-by-event cumulants of azimuthal angles. Their measurements will provide new and independent constraints on the QGP properties, and in this contribution the first predictions from state-of-the-art theoretical models are presented [1].

We demonstrate how the new event-by-event cumulants of azimuthal angles can disentangle flow and nonflow contributions in the measured correlations. To achieve that goal, we present the first analytic solutions for the long-standing problem of combinatorial background in the measured correlations [2].

We conclude that the observed universality of flow measurements in pp, p-Pb and peripheral Pb-Pb collisions can be attributed solely to the interplay between nonflow correlations and combinatorial background, which always exhibits universal scaling as a function of multiplicity.

[1] A. Bilandzic, M. Lesch, C. Mordasini and S. F. Taghavi, arXiv:2101.05619

[2] A. Bilandzic, arXiv:2106.05760

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