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Mapping the longitudinal structure of QGP via nuclear deformations in heavy ion collisions

The initial longitudinal structure of QGP is essential for understanding its formation, evolution, and properties in heavy-ion collisions. However, current flow decorrelation methods are limited by non-flow contamination, restricting access to the QGP's full longitudinal profile. By comparing collisions involving nuclei of similar masses but different deformations, we introduce a new approach that varies the initial conditions independent of non-flow. This method enabled us to uncover multiple components of the longitudinal structure of elliptic flow (v_2) [1] and to develop a novel technique for extracting flow decorrelations across the entire rapidity range [2]. We demonstrate the robustness of our approach using full 3D hydrodynamic and transport models. We reveal that while deformation enhances the overall magnitude of v_2, it leaves the long-range component of its longitudinal profile unchanged. Additionally, we discovered two distinct components of the longitudinal structure: a global twisted geometry and localized rapidity fluctuations contributing to short- and medium-range flow decorrelations. This study presents a new way to disentangle long- and short-range flow decorrelations from non-flow backgrounds, providing a concrete example of how leveraging the structure differences between isobar nuclei can help us gain new insights into the initial conditions of heavy-ion collisions.

[1] Sources of longitudinal flow decorrelations in high-energy nuclear collisions, https://arxiv.org/abs/2408.15006

[2] Longitudinal Structure of Quark-Gluon Plasma Unveiled Through Nuclear Deformations, https://arxiv.org/abs/2405.08749

Category

Theory

Collaboration (if applicable)

Authors: LUMENG, Liu (Fudan University); HUANG, Shengli; Dr ZHANG, Chunjian (Fudan University); JIA, Jiangyong (Stony Brook University (US)); BHATTA, Somadutta (Stony Brook University (US))

Presenter: LUMENG, Liu (Fudan University)

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