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Going against the flow: Revealing the QCD degrees of freedom in hadronic collisions

In this talk, we demonstrate that in smaller systems, such as proton–proton and peripheral ion–ion collisions, microscopic models for final state interactions, can produce anisotropies where the elliptic flow is *negative* — that is, the momentum is largest along the major axis, contrary to hydrodynamic predictions [1].

We present results from two distinct microscopic models: one based on repulsion between string-like fields and another based on effective kinetic theory. For both models, we first study the elliptic flow response to initial geometrical deformations in a simplified setup using toy models. This allows us to examine the dynamical origin of the negative sign of elliptic flow through its dependence on the ratio of system size to interaction length. We then proceed to look at more realistic scenarios, using the Angantyr model [2] in PYTHIA [3] for the case of string shoving, as well as the parton cascade ALPACA [4] based on the effective kinetic theory formulated by Arnold, Moore and Yaffe [5]. Both models show a clear transition between negative and positive elliptic flow as a function of system size for the examined small collision systems.

The negative sign of elliptic flow is a solid prediction of the string interaction model while in the model based on kinetic theory it is linked to a finite interaction range. Consequently, an experimental determination of the sign of elliptic flow, will provide novel insights into the degrees of freedom governing strong nuclear interactions in high-energy collisions and the way in which they interact.

[1] C. Bierlich et al., arXiv:2409.16093 [hep-ph]
[2] C. Bierlich et al., JHEP 10, 134 (2018), arXiv:1806.10820 [hep-ph]
[3] C. Bierlich et al., SciPost Phys. Codeb. 2022, 8 (2022), arXiv:2203.11601 [hep-ph]
[4] A. Kurkela et al., Eur. Phys. J. C 84, 74 (2024), arXiv:2211.15454 [hep-ph]
[5] P. B. Arnold et al., JHEP 01 (2003), 030, arXiv:0209353 [hep-ph]

Category

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Authors: BIERLICH, Christian (Lund University (SE)); GUSTAFSON, Gosta (Lund University (SE)); ZAPP, Korinna (Lund University (SE)); LÖNNBLAD, Leif (Lund University (SE)); CHRISTIANSEN, Peter (Lund University (SE)); TÖRNKVIST, ROBIN (Universidade de Santiago de Compostela - IGFAE)

Presenter: TÖRNKVIST, ROBIN (Universidade de Santiago de Compostela - IGFAE)

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