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## QGP vortex rings as a new probe for jet-induced medium response and longitudinal dynamics

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Hydrodynamics provides quantitative descriptions of various flow measurements in heavy-ion collisions, suggesting the strongly-coupled nature of the hot QCD matter. A ubiquitous phenomenon in fluid dynamics is the formation of vortex rings. In heavy-ion collisions, different conditions can give rise to toroidal vortex structure in the QGP medium, such as the medium's response to jet thermalization [1] and the early-stage longitudinal dynamics in asymmetric collisions [2]. Considering these scenarios, in this talk, we will present a systematic study of how  $\Lambda$  hyperon's polarization can probe these toroidal vortex structures in QGP. We define a "ring observable" in terms of the  $\Lambda$  production plane polarization [2]. It represents a measure of the effects caused by the vorticity induced in the ring formation. By conducting event-by-event analysis with the state-of-the-art (3+1)D theoretical framework [3, 4], we demonstrate that this ring observable is a highly sensitive probe for thermalizing energy-momentum currents deposited from high-energy jets and for the early-time longitudinal dynamics in asymmetric collision systems. An experimental indication of such "smoke rings" formed in the QGP would represent a significant advancement in studying the emergent phenomena of many-body QCD at multiple length scales.

[1] W. M. Serenone, D. D. Chinellato, M. A. Lisa, C. Shen, J. Takahashi and G. Torrieri, " $\Lambda$  polarization from thermalized jet energy", *Phys. Let. B* 820, 126500 (2021)

[2] M. A. Lisa, J. G. P. Barbon, D. D. Chinellato, W. M. Serenone, C. Shen, J. Takahashi and G. Torrieri, "Vortex rings from high energy central p+A collisions", *Phys. Rev. C* 104, no.1, 011901 (2021)

[3] V. H. Ribeiro, W. M. Serenone, D. D. Chinellato, M. A. Lisa, C. Shen, J. Takahashi and G. Torrieri, " $\Lambda$  polarization from vortex ring as medium response for jet thermalization", arXiv:2305.02428 [hep-ph] (2023)

[4] C. Shen and B. Schenke, "Longitudinal dynamics and particle production in relativistic nuclear collisions", *Phys. Rev. C* 105, no.6, 064905 (2022)

### Category

Theory

### Collaboration (if applicable)

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