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Hydrodynamic fluctuations in relativistic heavy-ion collisions

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We present a novel approach to the treatment of thermal fluctuations in the (3+1)-D viscous hydrodynamic simulation MUSIC. We investigate the phenomenological impact of thermal fluctuations on hadronic and electromagnetic observables using the state-of-the-art IP-Glasma + hydrodynamics + hadronic cascade hybrid approach [1]. In particular, we show that these thermal fluctuations influence the result of elliptic and triangular flow measurements for ultra-central collisions, such as those presented by the CMS Collaboration [2]. Consequences on the extraction of QCD transport coefficients from heavy-ion collisions will also be discussed.

The anisotropic flow observed in heavy-ion collision experiments is mostly attributed to the hydrodynamic response to the event-by-event collision geometry and to the sub-nucleon quantum fluctuations. However, hydrodynamic fluctuations are present during the dynamical evolution of the Quark Gluon Plasma (QGP) and are quantified by the fluctuation-dissipation theorem [3]. They can leave their imprint on final-state observables.

By analyzing the thermal noise mode-by-mode, we provide a consistent scheme of treating these fluctuations as the source terms for hydrodynamic fields. These source terms are then evolved together with hydrodynamic equations of motion. Such a treatment captures the non-perturbative nature of the evolution for these thermal fluctuations.

[1] McDonald, S., Shen, C., Fillion-Gourdeau, F., Jeon, S. and Gale, C., Phys. Rev. C 95, 064913 (2017).

[2] The CMS collaboration, Chatrchyan, S., et al., JHEP (2014) 2014:88.

[3] Kapusta, J. I., Müller, B. and Stephanov, M., Phys. Rev. C 85, 054906 (2012).

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