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Hypercontractivity and factorial moment scaling in the symmetry broken phase

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We perform a theoretical interpretation of the results on intermittency analysis recently presented by the STAR collaboration at RHIC (Phys. Lett. B 845, 138165 (2023), arXiv:2301.11062v1 [nucl-ex]). The main task in this analysis was the search for the scaling law relating higher order factorial moments in transverse momentum space with the second order one. In a more general context, such a scaling, as well as the associated power-law exponent $\nu \approx 1.304$, have been proposed as a signal for the approach to criticality from the hadronic phase (Phys. Rev. Lett. 69, 741 (1992)). Here we show that hypercontractivity, a general property of independent random variables in a higher dimensional space, dictates that such a scaling behaviour is prohibited in the asymptotic limit $q \to \infty$. Thus, the proposed scaling behaviour can only hold for q $lesssimq_{max}$. However, in such a case there is a wide class of distributions, not related to criticality, leading to this behaviour with exactly the same ν-value. We provide examples supporting this statement. Then, we explain the origin of ν-values less than one, measured in STAR for all analysed data sets. We demonstrate that they emerge naturally when the observed power-law behaviour refers to the factorial moment difference ΔF_q after the subtraction of the corresponding background, providing also some sufficient condition leading to $\nu < 1$.

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