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Accessing topological fluctuations of gauge fields with the chiral magnetic effect

Gauge fields provide the fundamental interactions in the Standard Model of particle physics. Gauge field configurations with nontrivial topological windings are known to play crucial roles in many important phenomena, from matter-antimatter asymmetry of today' s universe to spontaneous chiral symmetry breaking in strong interaction. Their presence is, however, elusive for direct detection in experiments. Here we show that measurements of the chiral magnetic effect (CME) in heavy ion collisions can be used for accessing the topological fluctuations of the non-Abelian gauge fields in the quantum chromodynamics (QCD). To achieve this, we implemented a key ingredient, the stochastic dynamics of gauge field topological fluctuations, into a state-of-the-art framework for simulating the CME in these collisions. This new framework provides the necessary tool to quantify initial topological fluctuations from any definitive CME signal to be extracted from experimental data. It also reveals a universal scaling relation between initial topological fluctuations and particle multiplicity produced in the corresponding collision events.

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