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Field theoretic perspectives of the chiral magnetic effect with a nonconstant axial chemical potential

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I will report our works about the field theoretic perspectives of the anomalous transports, especially with a nonconstant axial chemical potential [1,2]. We assess the applicability of the Wigner function formulation in its present form to the chiral magnetic effect and note some issues regarding the conservation and the consistency of the electric current in the presence of an inhomogeneous and time-dependent axial chemical potential. The problems are rooted in the ultraviolet divergence of the underlying field theory associated with the axial anomaly and can be fixed with the Pauli-Villars regularization of the Wigner function. The chiral magnetic current with a nonconstant axial chemical potential is calculated with the regularized Wigner function and the phenomenological implications are discussed. In addition, we study analytically the one-loop contribution to the chiral magnetic effect (CME) using lattice regularization with a Wilson fermion field [3]. In the continuum limit, we find that the chiral magnetic current vanishes at nonzero temperature but emerges at zero temperature consistent with that found by Pauli-Villas regularization. For finite lattice size, however, the chiral magnetic current is nonvanishing at nonzero temperature. But the numerical value of the coefficient of CME current is very small compared with that extracted from the full QCD simulation for the same lattice parameters. The possibility of higher-order corrections from QCD dynamics is also assessed.

[1] Yan Wu, Defu Hou and Hai-cang Ren, Phys. Rev. D 96 (2017), 096015;
[2] Defu Hou, Hui Liu and Hai-cang Ren, JHEP 1105 (2011) 046;
[3] Bo Feng, Defu Hou , Hai-cang Ren, Yan Wu, Phys. Rev. D 95 (2017) , 114023.

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