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Fluctuations of conserved charges in strong magnetic fields

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Strong magnetic fields are created at the early stage of non-central heavy-ion collisions. However, whether the magnetic fields survive in the late stage of heavy-ion collisions and experimental measurements of various observables are reminiscent of the initially-created magnetic fields still remain elusive. In this talk we show that fluctuations of and correlations among net baryon number, strangeness and electrical charge can be useful to probe the imprint of the magnetic field in heavy-ion collisions. This is based on the fact that 1) these fluctuations and correlations have been shown to be very useful in understanding the QCD phase structure in the vanishing magnetic fields and 2) our very recent lattice QCD studies on these quantities in magnetic fields.

We will show the first lattice QCD results of the second-order fluctuations of and correlations among net baryon number, electric charge and strangeness in (2+1)-flavor lattice QCD in the presence of a background magnetic field. Lattice QCD simulations are performed on 32^3×⊠⊠ lattices using the highly improved staggered fermions in a fixed scale approach with ⊠⊠∈[8,96] [1,2]. We study these quantities from zero temperature up to ~1.7 ⊠⊠⊠ with 15 values of the magnetic field strength ⊠⊠∈[0,60m_π^2] with pion mass m_π=220 MeV [1]. We also extend the above lattice QCD studies to the realistic case with physical pion mass m_π=135 MeV, and focus on a smaller temperature interval around the pseudo-critical temperature ranging from 0.9 ⊠⊠⊠ to 1.1 ⊠⊠⊠. To mimic the magnetic field strength produced in the early stage of heavy-ion collision experiments we now have 6 different values of the magnetic field strength up to ~10m_π^2 with m_π=135 MeV [3].

We discuss the temperature and ⊠⊠ dependences of the second-order fluctuations of and correlations among net baryon number, electric charge and strangeness. We find that these second-order fluctuations and correlations are substantially affected by ⊠⊠. They even develop peak structures at sufficiently large ⊠⊠ which could be related to a possible critical end point in the ⊠–⊠⊠ plane. We propose to investigate these quantities in experiments in different centrality classes and collision systems where ⊠⊠ could be different.

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