Contribution ID: **118** Type: **not specified**

Chiral properties of (2+1)-flavor QCD in background magnetic fields at zero temperature

We show our lattice QCD results for masses and magnetic polarizabilities of light and strange pseudo-scalar mesons, chiral condensates, decay constants of neutral pion and neutral kaon in the presence of background magnetic fields with eB ranging up to around 3.35 GeV^2 ($\sim$ 70 M_π^2) in the vacuum. We performed (2+1)-flavor QCD lattice simulations using the Highly Improved Staggered Quarks (HISQ) action with $N_\tau = 96$. In the simulation the strange quark mass is fixed to its physical quark mass $m_s^{\rm phy}$ and light quark mass is set to $m_s^{\rm phy}/10$ which corresponds to $M_\pi \approx 220$ MeV at zero temperature. We find that as the magnetic field strength grows, the masses of neutral pseudo-scalar mesons monotonously decrease and then saturate at a nonzero value, while there exists a non-monotonous behavior of charged pion and kaon masses as magnetic field grows. We observe a qB scaling of the up and down quark flavor components of neutral pion mass, neutral pion decay constant as well as the up and down quark chiral condensates at 0.05
$lesssim eB$
$lesssim$ 3.35 GeV^2. We show that the correction to the Gell-Mann-Oakes-Renner relation involving neutral pion is less than 6%, and the correction for the relation involving neutral kaon is less than 30% at eB
$lesssim$ 3.35 GeV^2.

We further find that the Ward Identity involving the space-time sum of the pseudo-scalar correlation functions and the chiral condensates, together with the GMOR relation, naturally reconciles magnetic catalysis at zero temperature and the reduction of transition temperature in a background magnetic field. This talk is based on arXiv:2008.00493.

Topics

Chiral Magnetic Effect

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