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# Criticality of QCD in correlated Dirac eigenvalues

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We present a first study on the correlated Dirac eigenvalues in the vicinity of the chiral phase transition of $N_f$=2+1 QCD. We analyze the quark mass and temperature dependences of the first and second order quark mass derivatives of Dirac eigenvalue spectrum, i.e. $\partial\rho/\partial m_l$ and $\partial^2\rho/\partial m_l^2$. This is done through the correlated Dirac eigenvalues based on a novel method [1]. Simulations are performed at temperatures from about 137 MeV to 176 MeV on $N_\tau = 8$ lattices using the highly improved staggered quarks and the tree-level improved Symanzik gauge action.
The strange quark mass is fixed to its physical value $m_s^{\rm phy}$ and the light quark mass $m_l$ is set to $m_s^{\rm phy}/20$, $m_s^{\rm phy}/27$, $m_s^{\rm phy}/40$, $m_s^{\rm phy}/80$ that correspond to the Goldstone pion masses $m_\pi \approx 160, 140, 110, 80$ MeV, respectively [2].

In sharp contrast to our findings at high temperature of $1.6\ T_c$ [1], $\rho$ is no longer proportional to $m_l^2$ in the vicinity of the chiral phase transition. Instead, we observe that $\partial\rho/\partial m_l/\chi_{\rm disc}$ and $\partial^2\rho/\partial m_l^2/\chi_2$ are quark mass and temperature independent at $T \in [137, 153]$ MeV, where $\chi_{\rm disc}$ is the disconnected chiral susceptibility and $\chi_2$ is part of quark mass derivative of $\chi_{\rm disc}$ that is related to $\partial^2\rho/\partial m_l^2$. Based on this observation in the vicinity of the chiral phase transition temperature, we will discuss the connection between the criticality of chiral phase transition and Dirac eigenvalue spectrum as well as its quark mass derivatives.

**References**

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