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Eigenvalue spectrum of 2+1 flavor QCD using highly improved staggered quarks

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The transition from hadron to the quark-gluon plasma phase is a smooth crossover in QCD with physical quark masses, nevertheless, the (almost) chiral nature of the light quarks is believed to drive such a transition. This phenomenon can be studied using lattice QCD techniques and the most popularly used fermion discretization, the staggered fermions only have a remnant of the full chiral symmetry of QCD, which is (perturbatively) believed to be recovered in the continuum limit. We for the first time study the eigenvalue distribution of the QCD Dirac operator with highly improved staggered quark discretization as a function of three different lattice spacings across the crossover transition temperature T_c, and perform the continuum extrapolation. From the features of the eigenvalue spectrum, we can conclude that though the flavor non-singlet part of the chiral symmetry is restored above T_c the flavor singlet $U_A(1)$ part of it remains broken. Moreover, we observe a level repulsion between the infrared eigenvalues is quadratic to the spacing similar to the Gaussian unitary ensemble(GuE) of chiral random matrix theory, unlike the near-zero modes. The consequences of these findings will be discussed.

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