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The Chiral Condensate of One-Flavor QCD and the Dirac Spectrum at $\theta = 0$

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In a sector of fixed topological charge, the chiral condensate has a discontinuty given by the Banks-Casher formula also in the case of one-flavor QCD. However, at fixed θ angle, the chiral condensate remains constant when the quark mass crosses zero. To reconcile these contradictory observations, we have evaluated the spectral density of one-flavor QCD at $\theta = 0$. For negative quark mass, it becomes a strongly oscillating function with a period given by the inverse space-time volume and an amplitude that increases expoentially with the space-time volume. As we have learned from QCD at nonzero chemical potential, if this is the case, an alternative to the Banks-Casher formula applies, and we will demonstrate that for one-flavor QCD, this results into a continuous chiral condensate. A special role is played by the topological zero modes which have to be taken into account exactly in order to get a finite chiral condensate in the thermodynamic limit.

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