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$U(1)_A$ breaking in hot QCD in the chiral limit

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We propose a simple instanton-based random matrix model of hot QCD that in the quenched case precisely reproduces the distribution of the lowest lattice overlap Dirac eigenvalues. Even after including dynamical quarks the model can be easily simulated in volumes and for quark masses that will be out of reach for direct lattice simulations in the foreseeable future. Our simulations show that quantities connected to the $U(1)_A$ and $SU(N_f)_A$ chiral symmetry are dominated by eigenvalues in a peak of the spectral density that becomes singular at zero in the thermodynamic limit. This spectral peak turns out to be produced by an ideal instanton gas. By generalizing Banks-Casher type integrals for the singular spectral density, definite predictions can be given for physical quantities that are essential to test chiral symmetry breaking, but presently impossible to compute reliably with direct lattice simulations.

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