



Bethe Colloquium

Andreas Ringwald

DESY

CP Violation and the Ordering of Limits in QCD with a Theta Parameter

We investigate the relation between CP violation and the ordering of limits in QCD with a θ parameter. Starting from the exact canonical partition function defined by the trace of the Boltzmann operator, we show that taking the thermodynamic limit at fixed topological charge yields a vacuum energy density independent of θ , leading to an apparent absence of CP violation. This behavior is a general property of constrained ensembles and does not reflect the physical properties of the theory. The θ -dependence of the vacuum energy arises from topological fluctuations of order $Q \sim \sqrt{V}$, which are removed if the thermodynamic limit is taken before summing over topological sectors. Our results clarify recent observations obtained with the reversed order of limits and show that they are not specific to particular models or to the number of quark flavors.

BCTP, Room W 2.019 - Wegelerstr. 10 - 53115 Bonn
Thursday, April 16, 2026 at 4:15 p.m.

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