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Semiclassics for QCD vacuum structure via T^2 compactification

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In this talk, we explore the QCD vacuum structure with topological theta angle, employing a novel semiclassical framework on $\mathbb{R}^2 \times T^2$ with 't Hooft and baryon magnetic fluxes. Grounded in the adiabatic continuity conjecture, the semiclassical analysis at small T^2 can capture the QCD vacuum structure, and the confining vacuum is described by the dilute gas of center vortices. Our 2d effective theory at small T^2 explains a plausible θ-dependence of the QCD vacuum: (1) The one-flavor QCD exhibits the CP-broken two-fold degenerate vacua at $\theta = \pi$ for quark mass above a critical value, and (2) the multi-flavor QCD shows the CP-breaking at $\theta = \pi$ for all (degenerate) quark masses. This 2d effective theory can be regarded as a 2d analog of the chiral Lagrangian with periodicity-extended eta prime. Intuitively, eta prime extends its periodicity by "eating" the $\mathbb{Z}_N$ SPT label of the $SU(N)$ Yang-Mills vacuum. Based on this observation, we point out that the periodicity extension of eta prime can improve the consistency of the 4d chiral Lagrangian with known global structures, such as discrete anomalies.

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