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A new perspective on thermal transition in QCD

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Motivated by the picture of partial deconfinement developed in recent years for large-N gauge theories, we propose a new way of analyzing and understanding thermal phase transition in QCD. We find nontrivial support for our proposal by analyzing the lattice configuration for 4d SU(3) QCD with dynamical quarks, produced by WHOT-QCD collaboration. In the discussion, the Polyakov line plays a crucial role in characterizing the phases at large N and finite N, without relying on center symmetry. Confinement at low temperatures is characterized by the Haar-random distribution of the Polyakov line phases. Haar-randomness, which is stronger than unbroken center symmetry, indicates that Polyakov loops in any nontrivial representations have vanishing expectation values and deviation from the Haar-random distribution at higher temperatures is quantified with the loops. We discuss that the transitions separating the partially-deconfined phase are characterized by the behaviors of Polyakov loops in various representations. As a nontrivial test for our proposal, we also investigate the relation between partial deconfinement and instanton condensation and confirm the consistency with the lattice data. This work is based on our recent works arXiv:2310.01940 and arXiv:2310.07533.

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