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Lattice QCD analysis for relation between quark confinement and chiral symmtery breaking

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In the lattice QCD formalism, we analytically derive a relation between the Polyakov loop and Dirac modes on the lattice where the temporal size is odd and link-variables are temporally periodic. The Polyakov loop is an order parameter for quark confinement and low-lying Dirac modes are essential for chiral symmetry breaking. Remarkably, from the relation, we find that low-lying Dirac modes have little contribution to the Polyakov loop [1,2], which indicates no direct one-to-one correspondence between confinement and chiral symmetry breaking in QCD. In the confinement phase, we also numerically find a new "positive/negative symmetry"of the Dirac-mode matrix element of the link-variable operator, and this symmetry leads to the zero value of the Polyakov loop [2]. Moreover, we derive a similar relation between the Wilson loop and Dirac modes [1].

References:
[1] H. Suganuma, T.M. Doi and T. Iritani, arXiv:1404.6494 [hep-lat]; Proc. Sci. (QCD-TNT-III) 042 (2014); EPJ Web of Conf. 71 (2014).
[2] T.M. Doi, H. Suganuma and T. Iritani, arXiv:1405.1289 [hep-lat]; Proc. Sci. (Lattice 2013) 375 (2013); Proc. Sci. (Hadron 2013) 122 (2014).

Summary

In the lattice QCD formalism, we analytically derive a relation between the Polyakov loop and Dirac modes, and find that low-lying Dirac modes have little contribution to the Polyakov loop analytically and numerically.

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