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Catalytic effect on pion decay caused by monopole and instanton creations in QCD

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Monopole condensation causes color confinement and instantons induce chiral symmetry breaking. Color confinement and chiral symmetry breaking are closely tied to one another through monopoles and instantons in the QCD vacuum. However, it is difficult to reveal the quantitative relations and effects among monopoles, instantons, color confinement, and chiral symmetry breaking by perturbative calculations because of the strong interaction in the low-energy region of the QCD. Therefore, we perform simulations of lattice gauge theory and investigate the impacts of the monopole and instanton creations on color confinement and chiral symmetry breaking.

In our research, we apply the monopole creation operator to the vacuum and add the monopoles and anti-monopoles to the SU(3) gauge field configurations of the quenched approximation. We vary the magnetic charges of the monopole creation operator to increase the number of monopoles and anti-monopoles.

We then calculate the eigenvalues and eigenvectors of the overlap Dirac operator that preserves the exact chiral symmetry in lattice gauge theory, using the normal configurations and the configurations to which the monopoles and anti-monopoles are added. We count the number of instantons and anti-instantons that are created by the additional monopoles and anti-monopoles. Finally, we investigate the impacts induced by monopole and instanton creations on observables that experiments can detect.

We have found the catalytic effect in which the lifetime of the charged pion becomes shorter than the experimental result by increasing the number density of the instantons and anti-instantons [1]. To my knowledge, no one has mentioned this effect before. We have demonstrated that the finite lattice volume and the discretization do not affect the outcomes that we obtained [2].

In my presentation, I would like to talk about the catalytic effect.

References

- [1] M. Hasegawa, *Monopole and instanton effects in QCD*, JHEP 09 (2020) 113, [arXiv: 1807.04808].
- [2] M. Hasegawa, *Color confinement, chiral symmetry breaking, and catalytic effect induced by monopole and instanton creations*, accepted by the EPJC on the 7th of October 2022, [arXiv: 2203.11357].

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