Quark-gluon mixed condensate $g\langle\bar{q}\sigma_{\mu\nu}G^{\mu\nu}q\rangle$ from lattice QCD

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Among many perspectives of QCD, the condensate works as one of the most important concepts, which can embody the non-perturbative properties of QCD. For instance, the chiral condensate $\langle\bar{q}q\rangle$ plays the key role in spontaneous chiral-symmetry breaking, and the gluon condensate $\frac{\alpha_s}{\pi}\langle G_{\mu\nu}G^{\mu\nu}\rangle$ has been extensively studied in the context of the trace anomaly. There are several methods which deal with these condensates. In particular, the QCD sum rule and lattice QCD are quite important in the sense that these two methods treat QCD directly without any reference to model-based degrees of freedom. However, each of these methods has its own advantages and disadvantages. Hence our aim is to evaluate condensates with lattice QCD in various circumstances, and consider its physical implications with the help of the QCD sum rules.
Using the QCD sum rules[1-3], the properties of hadrons such as hadron masses can be determined using these condensates as inputs. In addition, it can tell us what kind of condensate is important to the hadronic properties of concern. This is one of the advantages of the QCD sum rule. Some of the important condensates have been already determined within the QCD sum rule itself by using hadronic properties as inputs, vice versa. However, it is not always possible to evaluate condensates, especially in various physical circumstances. In order to overcome this problem, we can use lattice QCD and calculate such condensates directly from QCD. In this framework, we can freely change the physical circumstances such as temperature by hand. This freedom is the advantage of lattice QCD.
In this talk, we investigate another important condensate, quark-gluon mixed condensate $g\langle\bar{q}\sigma_{\mu\nu}G^{\mu\nu}q\rangle$. According to the QCD sum rules, this condensate has a significant influence on various baryon masses and the N-Δ mass splitting[4-5]. In addition, except for the ordinary chiral condensate $\langle\bar{q}q\rangle$, this is the lowest dimensional condensate, which works as another order parameter of chiral-symmetry breaking.
In spite of its importance, there is only a limited study from lattice QCD[6]. Therefore, as the first step, we have calculated $g\langle\bar{q}\sigma_{\mu\nu}G^{\mu\nu}q\rangle$ from lattice QCD, and compared it with the value obtained from the QCD sum rules. As the next step, by taking advantage of lattice QCD, we will calculate this condensate at finite temperature and discuss its physical consequences on the baryon masses.

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