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Fluctuation-induced effects in inhomogeneous chiral phases

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We discuss the effect of fluctuations for the inhomogeneous chiral phase in the thermodynamics of QCD.

Inhomogeneous chiral phase is characterized by the spatially modulated chiral condensate, $M(z) = -2G(\langle\bar{q}q\rangle + i\langle\bar{q}i\gamma_5\tau_3 q\rangle) = m(z)e^{i\theta(z)}$.
There are two typical types of condensates.
One is called real kink crystal (RKC), which is modulated only in the amplitude; $M(z) = m(z)$[1].
The other one is called dual chiral density wave (DCDW), which is modulated only in the phase; $M(z) = me^{i\theta(z)}$[2].
Here, we concentrate on the analysis for sinusoidal condensate.

Within the mean field approximation, it is known that there appears the inhomogeneous phase between the homogeneously broken and the normal phases in QCD phase diagram.
Both RKC and DCDW have characteristic behavior: there is the second order phase transition line between inhomogeneous and chiral restored phases.

If we consider the fluctuation effects, this behavior is remarkably changed.
Brazovskii has shown that the thermal fluctuation effect changes the order of phase transition between the inhomogeneous and normal phases [3].
Dyugaev has also shown that the quantum fluctuation induces similar effect [4].
Here, we develop these works and apply to the inhomogeneous chiral condensate: we consider both the thermal and quantum fluctuations.

As a result, we show the effects of the quantum and thermal fluctuations change the order of the phase transition.
Also we show that these effects disfavor the inhomogeneous condensate, the region of the inhomogeneous phase in QCD phase diagram is decreased.

Reference

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