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# Lifshitz point for the inhomogeneous chiral phase transition in the magnetic field

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The possible existence of the inhomogeneous chiral phase in the QCD phase diagram has recently received enhanced attention.
We elucidate some peculiar features of the inhomogeneous chiral phase in the magnetic field. Taking the dual chiral density wave (DCDW) [1], we have found that the energy spectrum of the Dirac operator exhibits the spectral asymmetry in the lowest Landau level, which is closely related to chiral anomaly [2]. It is a topological effect due to the phase od the chiral condensate inherent in the DCDW phase and gives rise to some interesting consequences such as a novel Lifshitz point [2], spontaneous magnetization [3] or appearance of the hybrid chiral condensate [4].
A new term appears in the generalized Ginzburg-Landau (gGL) expansion and the Lifshitz point appears on $\mu = 0$ in the chiral limit. Such point should be directly explored by the lattice QCD simulations [2].
We can further pursue the Lifshitz point in a realistic situation, where quark mass is finite. Within the gGL theory the thermodynamic potential should include an additional term proportional to the quark mass and disfavor DCDW: DCDW is greatly modified around the Lifshitz point by the mass term, and it is shifted to larger $\mu$. As a result one may expect a shift of the Lifshitz point from $\mu \sim 0$. On the other hand, it is well known that this term changes the usual chiral transition to be cross over at high temperature but small $\mu$. Note that the inhomogeneous to homogeneous phases should exhibit a clear phase transition due to the difference of symmetry between them.
We discuss how the finite mass effect modifies our earlier findings and some implications on the lattice QCD simulations.

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[3]R. Yoshiike, K. Nishiyama and T. Tatsumi, arXiv:1507.02110.
[4]K. Nishiyama and S. Karasawa and T. Tatsumi, Phys.Rev.D, to be published.

**Author:** TATSUMI, Toshitaka (Kyoto U.)

**Co-authors:** Mr NISHIYAMA, Kazuya (Kyoto University); YOSHIIKE, Ryo (Kyoto university)

**Presenter:** TATSUMI, Toshitaka (Kyoto U.)

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