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Crystalline chiral condensates in an external magnetic field

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We study the QCD phase diagram by the Nambu-Jona-Lasinio (NJL) model within the mean-field approach, taking into account both of the magnetic field and inhomogeneity of the chiral condensates.
For the analysis of the chiral inhomogeneous phase, the generalized chiral condensate $\Delta := -2G\left[\langle\overline{\psi}\psi\rangle + i\langle\overline{\psi}i\gamma^5\tau^3\psi\rangle\right]$ is used.
The dual chiral density wave (DCDW) and the real kink crystal (RKC) have been commonly used as typical form of the chiral condensate: DCDW is a plane wave configuration, $\Delta(x) = me^{iqx}$, and RKC is a multi-soliton configuration, $\Delta(x) = \frac{2m\nu}{1+\sqrt{\nu}}\mathrm{sn}\left(\frac{2mz}{1+\sqrt{\nu}}, \nu\right)$.
The thermodynamic properties of the DCDW phase in the magnetic field has been studied by Frolov et al., and it has been shown that the DCDW phase develops in the wide density region in the presence of the magnetic field.
However, they have only considered DCDW, while it has been suggested that the RKC phase may be favored without the external magnetic field.

Here we figure out the properties of the chiral inhomogeneous condensate in the presence of external magnetic field, taking into account the possibility of the RKC phase. We introduce a hybrid configuration (HCC) which has the feature of both DCDW and RKC,
$\Delta(x) = \frac{2m\nu}{1+\sqrt{\nu}}\mathrm{sn}\left(\frac{2mz}{1+\sqrt{\nu}}, \nu\right)e^{iqz}$, to this end.
Note that it smoothly connects both configurations by changing modulus ν.
There never appears the pure RKC phase, and DCDW and RKC coexist as HCC in the weak magnetic field at moderate density.
Eventually DCDW becomes most favorable in the strong magnetic field.
It is also shown that there is a first order phase transition between inhomogeneous phases in the presence of magnetic field.

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