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Spontaneous magnetization of quark matter in the inhomogeneous chiral phase

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Recently, a possible appearance of the inhomogeneous chiral phase has been extensionly studied by the use of the effective models of QCD like the NJL models. Here, we study the magnetic properties of the inhomogeneous chiral phase, taking the contribution of "dual chiral density wave (DCDW)"[1], where both scalar and pseudoscalar condensates are spatially modulated. We study the response of quark matter to a tiny external magnetic field to show the spontaneous magnetization in the DCDW phase. In an external magnetic field, the energy spectrum of quarks becomes asymmetric about zero in the lowest Landau level [2], and it gives rise to chiral anomaly [3].
We find that this spectral asymmetry also gives rise to the spontaneous magnetization, since a new term linearly proportional to the magnetic field is induced in the thermodynamic potential. Furthermore, this spontaneous magnetization includes not only the contribution of chiral anomaly [4] but also one of valence quarks. Such spontaneous magnetization might be a candidate of the origin of the strong magnetic field in neutron stars.
We also show the peculiar behavior of magnetic susceptibility at the ferromagnetic transition point: it never diverges unlike the usual ferromagnetic transition, which suggested a different mechanism of spontaneous magnetization from spin alignment.

References

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