

Anomalous Hall instability in chiral magnetohydrodynamics

The quark gluon plasma(QGP) is expected to exhibit a chiral imbalance known as the chiral anomaly which induces various anomalous currents, such as: the chiral magnetic effect(CME), the chiral vortical effect(CVE), the anomalous Hall effect(AHE) and so on. To describe these anomalous effects, one can use the chiral magnetohydrodynamics (CMHD).

We study the collective excitations and instabilities in a CMHD and focus on the anomalous Hall instability(AHI) which is due to the AHE in this talk.

Like the CME's instability, the AHI is dependent on the value of k and appears in a limited scope which is decided by the AHE coefficient ξ_H . Notably, the AHE does not trigger an instability by itself in a pure electrodynamic context without fluid, but it does in the CMHD. For small k expansion, we show that the Alfven wave modified by the AHE leads to an unstable solution. In particular, one can introduce an axion field $\theta(x)$ which interacts with the electromagnetic field in the form of $\theta E \cdot B$, to reproduce the AHE $\nabla \theta \times E$, the chiral chemical potential $\mu_5(x) \equiv \partial_t \theta$, where E, B are electric and magnetic fields, the AHE coefficient is $\xi_H \equiv \nabla \theta$. Because the AHI happens in a small scope and the total helicity is conserved, these give rise to a novel type of inverse cascade: the fermionic helicity will be transferred to various helicities of the small k modes. Then the AHI ceases eventually by depleting the value of μ_5, ξ_H .

Finally, we briefly discuss three different instabilities such as: the chiral plasma instability(CPI), the chiral magnetovortical instability(CMVI), the AHI and the possible relevance in QGP and other physical systems.

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