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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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