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Magnetohydrodynamics with chiral anomaly: phases of collective excitations and instabilities

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We study the relativistic hydrodynamics with chiral anomaly and dynamical electromagnetic fields. This theory is called the chiral magnetohydrodynamics (MHD) [1]. It is a framework that can evolve the system of QGP fluids and electromagnetic fields consistently, and it will play an important role in quantifying anomaly-induced effects in heavy-ion collisions. We formulate the chiral MHD as a low-energy effective theory based on a derivative expansion. We demonstrate that the modification of ordinary MHD due to chiral anomaly can be obtained from the second law of thermodynamics and is tied to the chiral magnetic effect with the universal coefficient. When the chirality imbalance exceeds a critical value, a new type of collective gapless excitation emerges, as a result of the interplay among magnetic field, flow velocity, and chiral anomaly; we call it the chiral magnetohelical mode (CMHM). These modes carry definite magnetic and fluid helicities and either grow exponentially or dissipate in time, depending on the relative sign between their helicity and axial charge density. The presence of exponentially growing CMHM indicates a hydrodynamic instability.

[1] Koichi Hattori, Yuji Hirono, Ho-Ung Yee, Yi Yin, "Magnetohydrodynamics with chiral anomaly: phases of collective excitations and instabilities,"[arXiv:1711.08450 [hep-th]].

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