Pions in a strong magnetic background *

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We investigate the modification of the pion self-energy at finite temperature due to its interaction with a low-density, isospin-symmetric nuclear medium embedded in a constant magnetic background.

Nuclear matter in strong magnetic fields

The study of nuclear matter under strong magnetic fields has acquired a lot of attention during the last years in the contexts of heavy ion collision physics and lattice QCD [1]. In Ref. [2] we investigate some properties of isospin-symmetric nuclear matter in the limit of low density and temperature, embedded in a strong magnetic background. In particular, we compute the in-medium pion effective mass in the presence of a constant magnetic field to one loop. For this purpose, we consider fully relativistic chiral perturbation theory as a framework for our computation. This is needed to define consistently the fermion propagators in a magnetic background.

Pion self-energy in strong magnetic fields

The leading order interaction Lagrangian, which describe the low-energy phenomenology of nuclear matter, $\mathcal{L}^{(1)}_{\pi N}$, reads [3]

$$\mathcal{L}^{(1)}_{\pi N} = -\bar{\Psi}\left[\frac{g_A}{2f_\pi}\gamma^\mu\gamma_5\tau\cdot\partial_\mu\pi + \frac{1}{4f_\pi^2}\gamma^\mu\tau\cdot(\pi\times\partial_\mu\pi)\right]\Psi. \quad (1)$$

Here τ is the vector of Pauli matrices in isospin space, π is the isotriplet of pions, f_π the pion decay constant and g_A is the axial-vector coupling.

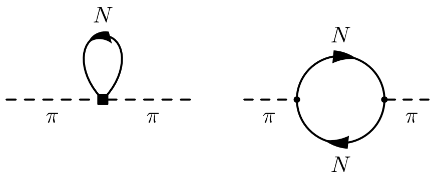

Figure 1: Diagrams contributing to the lowest-order in-medium pion self-energy.

The diagrams contributing to the pion self-energy from the Lagrangian (1) are shown in Fig. 1.

* The work of GC was supported by the HGS-HIRe graduate program at Frankfurt University. The work of ESF was financially supported by the Helmholtz International Center for FAIR within the framework of the LOEWE program (Landesoffensive zur Entwicklung Wissenschaftlich-Ökonomischer Exzellenz) launched by the State of Hesse.
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The effective pion mass is defined as:

$$m_\pi^{*\,2} = m_\pi^2 - \mathrm{Re}\,\Pi(m_\pi^{*\,2}, \mathbf{q}=0; \mathbf{B}) + (2n+1)|eB|\,, \quad (2)$$

where $\Pi(q)$ is the pion self-energy, $\mathbf{B}$ is the magnetic field and n is the index of the Landau level. The following results are computed within the lowest-Landau-level (LLL) approximation, which is valid for very intense magnetic fields.

Results

Fig. 2 displays our results for the pion effective mass, $\overline{m}_\pi$, as a function of the magnetic field, normalized to the trivial $|eB|$ shift in Eq. (2).

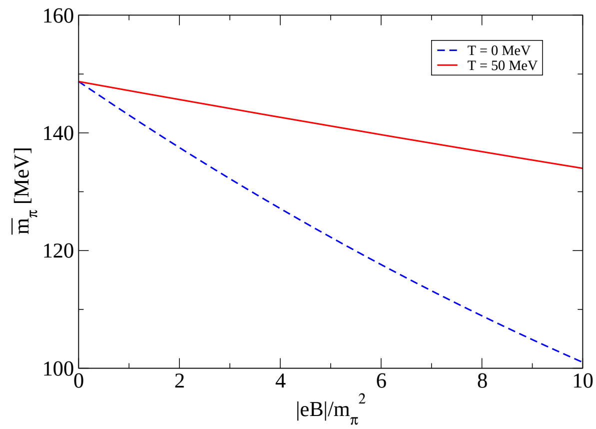

Figure 2: (Color online) Effective pion mass as a function of the magnetic field.

We find that the effective mass of the negatively charged pion drops by $\sim$ 10% for a magnetic field $|eB| \sim m_\pi^2$, which favors pion condensation at high density and low temperatures.

References

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 doi:10.15120/GR-2014-1-THEORY-14