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Thermomagnetic effects on light pseudoscalar meson masses within the SU(3) Nambu–Jona-Lasinio model

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In this work we use the Nambu–Jona-Lasinio model in its $SU(3)$ formulation, with the introduction of a six-point interaction given by the ‘t Hooft determinant to reproduce the breaking of the $U_A(1)$ symmetry.
Then, we apply the mean field approximation to obtain the effective quark masses and the stationary phase approximation in the bosonized NJL model to obtain the meson masses.
The inclusion of constant external magnetic fields is obtained in the Schwinger proper-time method, while the temperatures are included by the imaginary-time formalism in terms of the Matsubara frequencies.
These methods can be directly applied in the polarization functions of neutral meson mesons, and in the Ritus basis to the charged mesons.
Finally, for the regularization, we use the Magnetic Field Independent Regularization (MFIR) scheme, by separating the magnetic and thermal contributions to the vacuum ones, which avoids nonphysical oscillations in the quark condensates.
In order to obtain inverse magnetic catalysis we employ a magnetic field dependent coupling, fitted with LQCD data.

As a consequence of adding an external magnetic field, the screening masses of the neutral mesons are split in two: the perpendicular and the parallel ones, with $m_{scr,\perp} > m_{scr,\parallel}$.
We find that, for the parallel masses, they increase with the temperature when we consider a coupling depending on the magnetic field; and they decrease when we consider a constant coupling.
For the perpendicular mass, considering a constant coupling they exhibit a nonmonotonical magnetic behaviour until they reach temperatures {\color{red}below} T
$lesssim$500 MeV, and after this they increase.
For a coupling depending on eB, they always increase with the magnetic field.
We only find the parallel masses for the charged mesons, that always increase with eB.
Also is important to emphasize that when we use a coupling depending on the magnetic field we are able to reproduce the effect of IMC, where the critical temperatures decreases with eB, a result that we cannot reproduce if the coupling is constant.
On the other hand, the MC effect is reproduced regardless of whether we use a coupling depending on the magnetic field or not.

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