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Mass splitting and spin alignment for ϕ mesons in a magnetic field in NJL model

Based on the Nambu-Jona-Lasinio (NJL) model, we develop a framework for calculating the spin alignment of vector mesons and applied it to study ϕ mesons in a magnetic field. We calculate mass spectra for ϕ mesons and observe mass splitting between the longitudinally polarized state and the transversely polarized state. The ϕ meson in a thermal equilibrium system is preferred to occupy the state with spin $\lambda = 0$ than those with spin $\lambda = \pm 1$, because the former state has smaller energy. As a consequence, we conclude that the spin alignment will be larger than 1/3 if one measures along the direction of the magnetic field, which is qualitatively consistent with the recent STAR data. Around the critical temperature $T_C = 150$ MeV, the positive deviation from 1/3 is proportional to the square of the magnetic field strength, which agrees with the result from the non-relativistic coalescence model. Including the anomalous magnetic moments for quarks will modify the dynamical masses of quarks and thus influence the mass spectra and spin alignment of ϕ mesons. The discussion of spin alignment in the NJL model may help us better understand the formation of hadron's spin structure during the chiral phase transition.

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