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In-medium properties of light mesons in magnetized matter - effects of (inverse) magnetic catalysis

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In-medium mass of the light vector mesons ρ, ω with $J^{PC} = 1^{--}$, and the parity partner of ρ, the axial-vector A_1 meson with $J^{PC} = 1^{++}$, are studied in the nuclear matter in presence of an external magnetic field, accounting for the effects of (inverse) magnetic catalysis. The in-medium partial decay widths of the possible $A_1 \to \rho\pi$ decay modes are studied from the in-medium masses of the initial and the final state particles, by applying a phenomenological Lagrangian to account for the $A_1\rho\pi$ interaction vertices. The masses are calculated within the QCD sum rule framework by taking the contributions up to dimension-six operators in the operator product expansion. The medium effects of density, magnetic fields etc. are incorporated through the light quark ($\sim \langle\bar{q}q\rangle;\ q = u, d$) and the scalar gluon condensates ($\sim \langle G^a_{\mu\nu}G^{a\mu\nu}\rangle$), as well as the light four-quark condensate ($\sim \langle\bar{q}q\rangle^2$). The condensates are calculated within the effective chiral $SU(3)$ model in terms of the medium modified scalar fields. The scalar isoscalar fields $\sigma \sim (\langle\bar{u}u\rangle + \langle\bar{d}d\rangle)$, $\zeta \sim \langle\bar{s}s\rangle$, scalar isovector $\delta \sim (\langle\bar{u}u\rangle - \langle\bar{d}d\rangle)$, and the scalar dilaton field χ simulates the scalar gluon condensate within the model. The effects of magnetic fields are taken into account due to the magnetized Dirac sea contribution along with the Landau energy levels of protons and anomalous magnetic moments (AMMs) of the nucleons in the magnetized nuclear matter within the chiral effective model framework. The effects of magnetized vacuum lead to an enhancement (reduction) of the light quark condensates with the magnetic field at the nuclear matter saturation density ρ_0 for zero (finite) AMMs of the nucleons, which gives rise to the phenomenon of magnetic (inverse) catalysis. Thus, the effects of (inverse) magnetic catalysis on the in-medium spectral properties of masses and decay widths of ρ, ω, and A_1 mesons lead to the modified spectral functions as well as their production cross-sections in the magnetized nuclear matter. This should have experimental observable consequences in the non-central, heavy-ion collision experiments, where a huge magnetic field can be generated during the early stages of the collisions accompanied by a low density medium. Hence, the magnetic field effect is studied till nuclear matter saturation density. The modifications in the light vector mesons can be measured through their direct electromagnetic decay into dileptons, where the dileptons do not suffer from strong interaction in the produced medium.

Reference:

"In-medium properties of light vector and axial-vector mesons - effects of Dirac sea", Pallabi Parui and Amruta Mishra, arXiv: 2209.02455 [hep-ph].

Primary authors: PARUI, Pallabi (Indian Institute of Technology Delhi); MISHRA, Amruta (Indian Institute of Technology Delhi)

Presenter: PARUI, Pallabi (Indian Institute of Technology Delhi)

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