2025 XQCD
THE 21ST INTERNATIONAL CONFERENCE ON QCD IN EXTREME CONDITIONS

Contribution ID: **88** Type: **Talk**

Finite spin density effects on the QCD phase transition in the linear sigma model

Wednesday, July 2, 2025 5:10 PM (20 minutes)

The experimental observation of the spin polarisation of the outgoing hadrons in non-central heavy ion collisions implies the existence of a strongly vortical QGP medium with finite spin density. We consider the effect of finite spin density on the QCD phase diagram using the Linear Sigma model coupled to quarks (LSMq). In our approach, we introduce the finite spin density via a quark spin potential (μ_s) in the canonical formulation of the spin operator, leading to a nonlinear modification of the energy dispersion relation. Besides an expected effect on the thermal fermion loop, the spin potential also enters non-trivially in the zero-point, temperature-independent part of the fermion loop. Employing renormalization techniques [1], we observe a substantial influence of this term on the phase structure of the system at nonnegligible μ_s/T. Taking both the thermal and the zero-point terms into account, we find the expectation value of the sigma condensate by minimizing the thermodynamic potential of the system. Our findings indicate that, starting from a chiral symmetry broken phase at small T and μ_s, the minima of the thermodynamic potential moves towards lower values of σ with increasing μ_s, indicating the restoration of chiral symmetry. This behaviour is consistent with the results from the first principle lattice simulations [2].

Keywords: Quark-Gluon-Plasma, chiral phase transition, spin potential.

References:

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Track Classification: Phase diagram and critical behaviour in QCD/QFT