Massive Yang-Mills for vector and axialvector spectral functions at finite temperature

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The spontaneous breaking of chiral symmetry (SBCS) in the QCD vacuum is induced by the formation of a (scalar) quark-antiquark condensate, which, however, is not an observable quantity. Rather, SBCS manifests itself in the excitations of the condensate, i.e., the hadron spectrum, where the degeneracy of chiral multiplets (or chiral "partners") becomes broken. Prominent examples are the massive splitting in the scalar-pseudoscalar channel (σ-π), the vector-axialvector (ρ-a_1) and the nucleon and its chiral partner (N-N*(1535)). Of particular interest is the vector channel, as the medium modifications of the ρ meson can be measured in experiment via dilepton invariant-mass spectra [1]. Utilizing QCD and Weinberg sum rules with in-medium order parameters from lattice QCD, it was found in Ref. [2] that the "melting-ρ" scenario, which describes available dilepton data, is compatible with chiral symmetry restoration. However, to unravel the mechanism underlying ρ-a_1 degeneration a microscopic chiral description of both vector (V) and axialvector (AV) spectral functions is needed.

Toward this goal we previously developed a Massive-Yang Mills (MYM) approach (introducing ρ and a_1 mesons into the chiral pion lagrangian), which, in particular, enabled the description of the measured vacuum AV spectral function thanks to a resummed ρ propagator in the a_1 selfenergy while preserving chiral Ward identities [3]. In the present work [4] we have implemented this approach into a finite-temperature pion gas by evaluating the vacuum loop diagrams using standard thermal-field theory techniques in the Matsubara formalism. Special care has been taken to satisfy the Ward identities for the (partially) conserved (axial-) vector current at finite temperature by systematically evaluating the medium corrections to all vertex correction diagrams.

The resulting spectral functions for MYM in the linear realization of chiral symmetry (linear σ model) are shown in Fig. 1. The a_1 resonance exhibits a large broadening and significant mass shift toward the ρ-meson mass, while the latter is essentially stable. At the same time, the chiral order

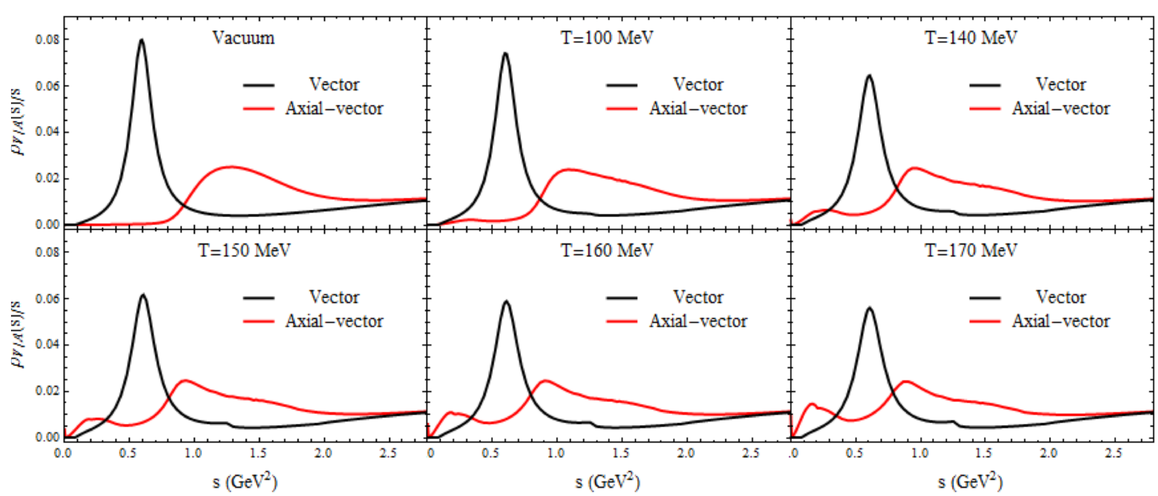

FIG. 1. Temperature progression of vector and axialvector spectral functions in a hot pion gas within the linear realization of Massive Yamg-Mills [4].

parameters calculated within the model, i.e., the pion decay constant and the scalar condensate, undergo a noticeable reduction of up to 15-20% at a temperature of T = 160 MeV. Very similar features are found when implementing MYM into the nonlinear pion lagrangian. Our findings can thus be considered robust and suggest that the approach toward chiral restoration (as indicated by the decrease of chiral order parameters) is realized by burning off the chiral mass splitting between ρ and a_1 mesons. This mechanism is remarkably similar to what we have found before using QCD and Weinberg sum rule techniques with a realistic in-medium ρ spectral function [2]. Such a mechanism has recently also been found in a lattice QCD computation of finite-temperature correlation functions of the nucleon and its chiral partner, the N*(1535); while the nucleon mass changed little with temperature, the N*(1535) mass drops toward the nucleon one, compatible with degeneration close to T_c.

Future work will be aimed at dressing the pion lines in the loop diagrams, and in particular include interactions with baryons into the MYM approach, as they are known to be an essential driver of the low-mass dilepton enhancement observed in heavy-ion experiments.

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