

Study of the scalar and pseudoscalar meson mass spectrum of QCD above the chiral transition, using an effective Lagrangian approach

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The fundamental theory of strong interactions, known as Quantum Chromodynamics (QCD), exhibits rich symmetry properties that underlie the behavior of hadronic matter. In the limit of N_f light quark masses, QCD possesses an approximate chiral symmetry $U(1)_V \otimes U(1)_A \otimes SU(N_f)_V \otimes SU(N_f)_A$. The special unitary part of this symmetry group is spontaneously broken to its vectorial subgroup $SU(N_f)_V$ at low temperatures, leading to the emergence of pseudo-Goldstone bosons. At temperatures above a critical value $T_c^{(N_f)}$, however, lattice simulations show that the chiral condensate $\langle \bar{\psi}\psi \rangle$, which is the order parameter of the breaking process, vanishes and the chiral symmetry $SU(N_f)_V \otimes SU(N_f)_A$ is approximately restored. Conversely, $U(1)_A$ symmetry remains broken at every temperature because of a quantum anomaly. Whether the $U(1)_A$ symmetry is effectively restored at temperatures higher than $T_c^{(N_f)}$, as the magnitude of the anomalous term decreases, remains a subject of active research.

In this work, expanding on previous analyses [1,2], we employ the extended linear sigma (EL_σ) model to investigate the mass spectrum of scalar and pseudoscalar mesons in a realistic $N_f = 2 + 1$ flavor scenario (with degenerate up and down quarks and a heavier strange quark: $0 < m_u = m_d \ll m_s$) above the critical temperature $T_c^{(N_f)}$. The model's predictions are then critically compared with available lattice QCD results [3], where meson screening masses are extracted from chiral susceptibilities, which correspond to two-point correlation functions of suitable interpolating operators. The expected restoration of chiral symmetry should manifest as degeneracies in correlators and screening masses for meson channels related by symmetry transformations.

1. Enrico Meggiolaro and Alessandro Mordà. Remarks on the $U(1)$ axial symmetry and the chiral transition in QCD at finite temperature. *Phys.Rev.D*, 88(9):096010, 2013.
2. Enrico Meggiolaro. Study (using a chiral effective Lagrangian model) of the scalar and pseudoscalar meson mass spectrum of QCD at finite temperature, above T_c . arXiv:2310.10339 [hep-ph].
3. Alexei Bazavov et al. Meson screening masses in (2+1)-flavor QCD. *Phys.Rev.D*, 100(9):094510, 2019.

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