High Energy Physics - Phenomenology

Properties of quarks and mesons in the Dyson-Schwinger/Bethe-Salpeter approach

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In this thesis, the Dyson-Schwinger - Bethe-Salpeter formalism is investigated and used to study the meson spectrum at zero temperature, as well as the chiral phase transition in finite-temperature QCD. First, the application of sophisticated matrix algorithms to the numerical solution of both the homogeneous Bethe-Salpeter equation (BSE) and the inhomogeneous vertex BSE is discussed, and the advantages of these methods are described in detail. Turning to the finite temperature formalism, the rainbow-truncated quark Dyson-Schwinger equation is used to investigate the impact of different forms of the effective interaction on the chiral transition temperature. A strong model dependence and no overall correlation of the value of the transition temperature to the strength of the interaction is found. Within one model, however, such a correlation exists and follows an expected pattern. In the context of the BSE at zero temperature, a representation of the inhomogeneous vertex BSE and the quark-antiquark propagator in terms of eigenvalues and eigenvectors of the homogeneous BSE is given. Using the rainbow-ladder truncation, this allows to establish a connection between the bound-state poles in the quark-antiquark propagator and the behavior of eigenvalues of the homogeneous BSE, leading to a new extrapolation technique for meson masses. This is used to study the ground- and excited-state meson spectrum for all quark masses from light to bottom, for pseudoscalar, scalar, vector, axialvector and tensor mesons. Good agreement with experiment is found, e.g., for all ground states in the bottomonium system. In addition, new applications of the inhomogeneous vertex BSE, such as the possibility to calculate on-shell quantities like decay constants, are investigated. Finally, we study the influence of the infrared behavior of the effective interaction on properties of pi and rho mesons.

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