Gluonic Profile and Confining String in Static Mesons and Baryons at Finite Temperature

Ahmed Saad El Bakry Mahmoud

Centre for the Subatomic Structure of Matter
School of Chemistry & Physics
University of Adelaide

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Ahmed Saad El Bakry Mahmoud

Dedication

To my family.

Abstract

The distribution of the gluon action density in mesonic systems is investigated at finite temperature. The simulations are performed in pure SU(3) Yang-Mills gauge theory for two temperatures below the deconfinement phase. The action-density isosurfaces display a prolate-spheroid-like shape. The curved width profile of the flux tube is found to be consistent with the prediction of the free bosonic string model at large distances.

In the intermediate source separation distance, where the free string picture poorly describes the flux tube width profile, we find the topological characteristics of the flux tube converge and compare favourably with the predictions of the free bosonic string upon reducing the vacuum action towards the classical instanton vacuum. As a byproduct of these calculations, we find the broadening of the QCD flux tube to be independent of the UV filtering at large distances. Our results exhibit a linearly divergent pattern in agreement with the string picture predictions.

We investigate the overlap of the ground state meson potential with sets of mesonic-trial wave functions. We construct trial states with non-uniform smearing profiles in the Wilson loop operator at $T = 0$. The non-uniformly UV-regulated flux-tube operators are found to optimize the overlap with the ground state.

The gluon flux distribution of a static three quark system has been revealed at temperatures near the end of the QCD plateau, $T/T_c \approx 0.8$, and another just before the deconfinement point, $T/T_c \approx 0.9$. The flux distributions at short distance separations between the quarks display an action-density profile consistent with a rounded filled Δ shape iso-surface. However the Δ shape action iso-surface distributions are found to persist even at large inter-quark separations. The action density distribution in the quark plane exhibits a nonuniform pattern for all quark separations considered. We systematically measure and compare the main aspects of the profile of the flux distribution at the two considered temperature scales for three sets of isosceles triangle quark configurations. The radii, amplitudes and rate of change of the width of the flux distribution are found to reverse their behavior as the temperature increases from the end of the QCD plateau towards the deconfinement point. Remarkably, we find the mean square width of the flux distribution shrinks and localizes for quark separations larger than 1.0 fm at $T/T_c \approx 0.8$ which results in an identifiable Y-shaped radius profile. Near the deconfinement point, the action-density delocalizes and the width broadens linearly with the quark separation at large quark separations.

We present a method to include the thermal effects into the junction width of the baryonic string model. The profile of the baryonic gluonic distribution is compared with the width of the string picture's junction fluctuations. The comparison reveals that the best fits to the junction fluctuations of the baryonic string are near the Fermat point of the triangle made up by the quarks. This result supports the underlying picture of Y-shaped string-like flux tubes connected at a junction.