Abstract:

We study the free energies of individual quarks in a finite volume with suitable boundary conditions to account for their Z3-valued electric flux. In order to demonstrate how 't Hooft's electric fluxes can be used to account for Gauss' law, we first use a Z3-Potts model as an effective Polyakov-loop theory for the heavy-dense limit of QCD at strong coupling, with interfaces to realize 't Hooft's twisted boundary conditions in temporal planes. The corresponding electric-flux ensembles, as discrete Fourier transforms of the temporally twisted ones, together with the static quark determinant of heavy-dense QCD are then equivalent to a modified flux-tube model. We use this equivalence to demonstrate how electric fluxes can be employed to prepare ensembles with quark numbers $N_q \neq 0 \bmod 3$ in a finite volume which is impossible with periodic boundary conditions because of the Roberge-Weiss symmetry that the effective theory shares with QCD. Moreover, using dualisation techniques for the fermion determinant, we show how this construction can be generalised to full QCD with dynamical Wilson fermions. A more rigorous formulation based on the transfer-matrix approach reveals further subtleties and leaves us with a puzzle.