Contribution ID: **111** Type: **Talk**

Grassmann bond-weighted tensor renormalization group approach to 1+1D two-color QCD with staggered fermions at finite density

Friday, 2 August 2024 14:15 (20 minutes)

Tensor renormalization group is expected to be a promising method to simulate lattice field theories at finite density since it does not suffer from the sign problem. We construct a Grassmann tensor network representing the partition function of 1+1D SU(2) lattice gauge theory coupled with staggered fermions. At finite couplings, a random sampling is applied to discretize the group integration. The initial bond dimension turns out to be $16K$ where K is the number of SU(2) matrices sampled for each link variable. We introduce an efficient initial tensor compression scheme to reduce the size of initial tensors. Then, Grassmann bond-weighted tensor renormalization group approach is adopted to investigate a phase diagram in the (m, μ) plane with the quark mass m and chemical potential μ. The free energy density, number density, and diquark condensate at different gauge couplings are computed as a function of the chemical potential. We discuss the efficiency of random sampling method, our initial tensor compression scheme, and the future application toward the corresponding higher-dimensional models.

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Session Classification: Theoretical developments

Track Classification: Theoretical Developments