

# Three ways of calculating composite-particle spectra of gauge theories in the Hamiltonian formalism

*Wednesday, 29 November 2023 15:15 (15 minutes)*

We propose three distinct methods to compute the mass of composite particles (hadrons) of gauge theories in the Hamiltonian formalism. Determination of the mass spectrum of hadrons is one of the key issues in QCD, which has been precisely calculated by the Monte Carlo simulation based on the Lagrangian formalism. We newly show how to compute the mass spectra in the Hamiltonian formalism, which is suitable for quantum computation and tensor network methods. The three methods, by examining the correlation function, the one-point function, and the dispersion relation, are demonstrated using the density-matrix renormalization group (DMRG) in the 2-flavor Schwinger model, which shares important properties with QCD. We show that their results are consistent with each other, and discuss their potential applications. (preprint: <https://arxiv.org/abs/2307.16655>)

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**Session Classification:** Parallel Session B