Contribution ID: **17**   Type: **not specified**

Three-dimensional Imaging of Pion using Lattice QCD: Generalized Parton Distributions

Monday 12 August 2024 13:45 (25 minutes)

We report a lattice calculation of x-dependent valence pion generalized parton distributions (GPDs) at zero skewness with multiple values of the momentum transfer $-t$. The calculations are based on an $N_f = 2 + 1$ gauge ensemble of highly improved staggered quarks with Wilson-Clover valence fermion. The lattice spacing is 0.04 fm, and the pion valence mass is tuned to be 300 MeV. We determine the Lorentz-invariant amplitudes of the quasi-GPD matrix elements for both symmetric and asymmetric momenta transfers with similar values and show the equivalence of both frames. Then, focusing on the asymmetric frame, we utilize a hybrid scheme to renormalize the quasi-GPD matrix elements obtained from the lattice calculations. After the Fourier transforms, the quasi-GPDs are then matched to the light-cone GPDs within the framework of large momentum effective theory with improved matching, including the next-to-next-to-leading order perturbative corrections, and leading renormalon and renormalization group resummations. We also present the 3-dimensional image of the pion in impact-parameter space through the Fourier transform of the momentum transfer $-t$.

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Session Classification: Presentations