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Unpolarized Nucleon TMDPDFs from Lattice QCD: I

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In this work, we present the first ab-initio numerical results of unpolarized proton's isovector transverse-momentum-dependent parton distribution functions (TMDPDFs), which are essential for exploring the inner pictures of nucleon, as well as for predicting the observables in multi-scale, non-inclusive high energy processes such as semi-inclusive deep-inelastic scattering and Drell-Yan scattering at the large hadron collider (LHC) or electron ion collider (EIC). We adopt a $N_f = 2+1+1$ MILC ensemble with valence clover fermions on a highly improved staggered quark sea (HISQ) to generate the Euclidean correlations related to quasi TMDPDFs, employ the state-of-art techniques in the processes as renormalization, extrapolation in correlation distance and so on. Associating with the up-to-date results of intrinsic soft function and Collins-Soper kernel, and introducing the renormalization group evolution improved one-loop matching in the framework of large-momentum effective theory (LaMET), we obtain the numerical results of light-cone TMDPDFs. In the uncertainties estimation, we explore the dependence on pion mass and hadron momentum, and take into account both statistical errors and systematic errors. The results shown in our manuscript give a reliable description of nucleons'inner structure from the view of the parton distribution, and also can be accessible to a wide community of collider physics.

Presenter: ZHANG, Qi-An (Beijing University of Aeronautics and Astronautics)

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