

## EDITORIAL: Special Issue on *Path Dependence in Quantum Physics*<sup>1</sup>

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The key conceptualization in contemporary Quantum Physics is based on local gauge invariance in terms of Wilson lines or loops. This applies invariably to QED and QCD with additional complications for the latter stemming from the fact that it is a non-Abelian gauge theory. However, the transcription of fundamental QCD quantities, like vacuum or hadronic correlation functions, in a manifestly gauge-invariant form entails, in general, a path dependence. Beyond the tree level of QCD perturbation theory, this path dependence gives rise to additional divergences caused by endpoints, cusps, or self-intersections that affect the renormalization-group and evolution properties of various QCD observables. These issues become more crucial in the case of transverse-momentum dependent distribution functions that describe basic QCD hadronic processes, like semi-inclusive deeply inelastic scattering, Drell–Yan, etc. and are the source of

asymmetries. Furthermore, the path dependence of the transverse-momentum dependent parton densities shows up decisively in the study of the three-dimensional structure of the nucleon, which is one of the hot topics in a number of current and planned experimental projects, such as the 12 GeV energy upgrade of the Jefferson Lab and Electron-Ion Collider. The underlying theoretical aspects (gauge invariance, factorization, renormalization, Makeenko–Migdal loop equations, soft factors, resummation of large perturbative logarithms, spin structure, etc.) of these observables and their phenomenological ramifications are addressed in this Special Issue with emphasis given to recent developments in the field.

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<sup>1</sup> The article is published in the original.