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Taming perturbation theory in QCD with Normalizing Flows

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When predicting the distribution of an observable, $p(x)$, in QCD, fixed-order (FO) perturbation theory can suffer from many undesirable artifacts, including large logarithms spoiling the expansion, unphysical divergences or negative bins, non-smooth kinks, and non-normalizability on physical x's. However, one expects the "true" $p(x)$, as accessed by experiment, to be finite, positive, smooth, and normalized. We show how these conditions on $p(x)$ can be enforced exactly by parameterizing it using a Normalizing Flow (NF), which is matched onto FO calculations in regions of x where perturbation theory is expected to converge, which results in a "more physical" $p(x)$ that still agrees with perturbation theory. This performs an effective resummation of higher-order terms in taming divergences, constrained at the lowest orders to the perturbative expansion by the choice of loss, of which the usual leading logarithmic resummation is one possibility. In principle, additional physical structure including scheme independence, RG evolution (including DGLAP), factorization, or other constraints can be incorporated into the NF.

Track

Theory

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