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Gauge-invariant renormalization of fermion bilinears and energy-momentum tensor on the lattice

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We study a gauge-invariant renormalization scheme (GIRS) for composite operators, regularized on the lattice, by extending the coordinate space (X-space) scheme proposed some years ago. In this scheme, Green's functions of products of gauge-invariant operators located at different spacetime points are considered. Due to the gauge-invariant nature of GIRS, gauge fixing is not needed in the lattice simulations. Also, when operator mixing occurs, the gauge-variant operators (BRST variations and operators which vanish by the equations of motion) can be safely excluded from the renormalization process.

We propose a number of variants of GIRS, including integration over time slices of the operator insertion point in a Green's function, which may lead to reduced statistical noise in lattice simulations. We employ these variants in the renormalization of fermion bilinear operators and the study of mixing between the gluon and quark energy-momentum tensor operators. We extract the one-loop conversion factors relating the nonperturbative renormalization factors in different versions of GIRS to the reference scheme of $\overline{\text{MS}}$.

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