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The Standard Model Gauge Group, SMEFT, and Generalized Symmetries

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We discuss heavy particles that can be used to pin down the faithful Standard Model (SM) gauge group and their patterns in the SM effective field theory (SMEFT). These heavy particles are not invariant under a specific $\mathbb{Z}_6$ subgroup of $SU(3)_c \times SU(2)_L \times U(1)_Y$, which however acts trivially on all the SM particles, hence the faithful SM gauge group remains undetermined. Different realizations of the faithful SM gauge group correspond to different spectra of heavy particles, and they also correspond to distinct sets of line operators with one-form global symmetry acting on them. We show that the heavy particles not invariant under the $\mathbb{Z}_6$ group cannot appear in tree-level ultraviolet completions of SMEFT, this enforces us to consider one-loop UV completions of SMEFT to identify the $\mathbb{Z}_6$ non-invariant heavy particles. We demonstrate with examples that correlations between Wilson coefficients provide an efficient way to examine models with $\mathbb{Z}_6$ non-invariant heavy particles. Finally, we prove that all the scalars that can trigger electroweak symmetry breaking must be invariant under the $\mathbb{Z}_6$ group, hence they cannot be used to probe the faithful SM gauge group.

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