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Towards the HEFT-hedron: the complete set of positivity constraints on HEFT operators at NLO

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We present the complete set of positivity bounds on the Higgs Effective Field Theory (HEFT) at next-to-leading order. We identify the 15 operators that can be constrained by positivity, as they contribute to s^2-growth in the amplitude for longitudinal gauge-Higgs scattering, that is to the $VV \to VV, hh, Vh$, and $hh \to VV, Vh$ processes, where $V = W^{\pm}, Z$, h is the observed Higgs boson, and s is the center-of-mass energy squared. We find two categories of constraints: (i) specific linear combinations of CP-even Wilson coefficients must be positive, and (ii) the magnitudes of some Wilson coefficients–including all CP-odd ones–must be smaller than products of other CP-even Wilson coefficients. Our results can thus provide indirect upper bounds on Wilson coefficients of the second category. Additionally, we obtain double-sided bounds on these Wilson coefficients by imposing unitarity and st-crossing symmetry. We present our final constraints on the 15 dimensional HEFT space as well as on the space of anomalous couplings and show how known positivity bounds on the 3 dimensional space of dimension 8 SMEFT can be recovered from them. For the $VV \to hh$ and $VV \to VV$ channels, we find that a significant portion of the parameter space is excluded by these requirements. In particular for quartic gauge couplings we find that less than 8% of the experimentally allowed parameter space is consistent with our positivity bounds. Furthermore, positivity constraints of the second category above imply upper bounds on Wilson coefficients contributing to the $VV \to Vh$ process from collider bounds on $VV \to VV, hh$ searches.

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