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Entropy constraints on effective field theory

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In effective field theory, the positivity bounds of higher derivative operators are derived from analyticity, causality, and unitarity. We show that the positivity bounds on a class of effective field theories, e.g., dimension-eight term of a single massless scalar field, the Standard Model Effective Field Theory dimension-eight $SU(N)$ gauge bosonic operators, and Einstein-Maxwell theory with higher-derivative operators, generated by interactions between heavy and light degrees of freedom can be derived by the non-negativity of relative entropy. For such a class of effective field theories, we prove that the interactions increase thermodynamic entropy at fixed energy and charge, which is intimately connected with the extremality relations of black holes exhibiting Weak-Gravity-Conjecture. These arguments are applicable when corrections from the interactions involving higher-derivative operators of light fields are not dominant in the effective field theories. The entropy constraint is a consequence of the Hermiticity of Hamiltonian, and any theory violating the non-negativity of entropy would not respect the second law of thermodynamics.

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