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First-order electroweak phase transition in the SMEFT

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A first-order Electroweak Phase Transition (FOEWPT) could explain the observed baryon-antibaryon asymmetry of the Universe, and its dynamics could yield a detectable gravitational wave signature, while the underlying physics would be within the reach of colliders. The Standard Model, however, predicts a crossover transition, so any hope of having a FOEWPT hinges on physics beyond the Standard Model (BSM). Most studies of the possibilities for a FOWEWPT consider new particles around the electroweak scale that contribute to the effective potential and help generate a barrier between the true and the false vacuum, facilitating a first-order transition.

On the other hand, the Standard Model Effective Field Theory (SMEFT) is a model-independent effective field theory extension of the SM that encodes new physics at the cutoff scale. It contains all SU(3)xSU(2)xU(1) invariant operators to a given order in the EFT expansion. Previous phenomenological studies of possibilities for a FOEWPT in the SMEFT have considered the case with a tree-level barrier and a negative Higgs quartic coupling. This requires a small new physics scale, which from an EFT perspective is undesirable. In a previous paper [1] we highlighted another possibility, where a FOEWPT is possible when the barrier between minima is generated radiatively, the quartic coupling is positive, the scale of new physics is higher, and there is good agreement with experimental bounds.

In this talk I will describe this work, and a continuation work where we make a systematic study of all possible types of phase transitions that occur in different regions of parameter space, with both tree-level barriers and radiatively generated barriers.

Our calculations are based on careful power counting of the scaling of parameters necessary to generate a barrier in the potential and are done in a consistent, gauge-invariant way. We perform global fits in the relevant parameter spaces and explicitly find points with a FOEWPT that agree with experimental data. We also briefly discuss the prospects for probing the allowed parameter space using di-Higgs production in colliders.

[1] J.E. Camargo-Molina, R. Enberg, J. Löfgren, "A new perspective on the electroweak phase transition in the Standard Model Effective Field Theory", JHEP 2021, 127 (2021), arXiv:2103.14022

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