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EW Vacuum Decay Induced by Domain Walls in the N2HDM

The Next-to-Two-Higgs-Doublet model (N2HDM) has a rich vacuum structure where multiple electroweak (EW) breaking minima, as well as CP and electric-charge breaking minima, can coexist. These minima can be deeper than the electroweak vacuum $v_{ew} \approx 246$ GeV of our universe, making our vacuum metastable. In such a case, one needs to calculate the tunneling rate from the EW vacuum to the deeper minimum. If the decay rate is larger than the universe's age, our vacuum is deemed long-lived, and the parameter point is in principle allowed. If the decay rate is smaller than the universe's age, then our vacuum is unstable and the parameter point is ruled out. However, domain walls (DW) in the N2HDM can substantially alter this picture. We show in this work that inside the DW, the barrier between our electroweak minimum and the deeper minimum can disappear, leading the scalar fields to classically roll over to the deeper minimum that nucleates inside the DW and then expands outside of it everywhere in the universe. We show that such behavior can happen to parameter points where the lifetime of our vacuum is several orders of magnitude larger than the age of the universe, making these parameter points with very long-lived EW minimum ruled out.

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