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Symmetry Breaking in the Scalar Higgs Potential

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From the Great Pyramids of Giza to snowflakes, symmetries are everywhere. But symmetries lie deeper than snowflakes, even deeper than molecules! For something to be symmetrical, it remains unchanged under some transformation. Symmetries can also be broken. This occurs when an object's symmetry changes after it goes through some transition. This concept extends into the fundamental particles that make up the Universe. These symmetries are accounted for by the Standard Model Lagrangian, which is a mathematical formulation of most of the fundamental forces that we observe: electromagnetism, the strong nuclear force, and the weak nuclear force. We are investigating a scalar Higgs potential model in order to understand symmetry breaking. This term accounts for the spontaneous symmetry breaking mechanism. By applying a symmetry group transformation onto the critical points of the scalar Higgs potential, we can examine exactly where symmetry breaking occurs. This will carry on to future work where we look at this concept from a topological understanding using Morse theory, which allows us to find topological invariants using special equations, which will be derived from the scalar Higgs potential. Using this, we can put a limit on the number of symmetry-breaking patterns for different groups, and by virtue, different models. By developing our topological understanding of symmetry and symmetry breaking classically, we also hope to see if we can learn anything about the quantum effects of symmetry breaking through the lens of topology, while also being able to apply this to other models that describe symmetry.

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